

SCIENTIFIC REPORTS

OF THE

Agricultural Research Institute, Pusa

*(Including the Reports of the Imperial Dairy Expert,
Physiological Chemist, Government Sugarcane Expert,
and Secretary, Sugar Bureau)*

1928-29



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Scientific Reports of the Agricultural Research Institute, Pusa

(Including the Reports of the Imperial Dairy Expert, Physiological Chemist, Government Sugarcane Expert, and Secretary, Sugar Bureau)

1928-29

REPORT OF THE DIRECTOR.

(W. McRAE, M.A., D.Sc., F.L.S., and F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.)

I. CHARGE AND STAFF.

Charge. Dr. D. Clouston, C.I.E., held charge of the office of Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, up to 11th April, 1929, when he proceeded on leave, preparatory to retirement, after having made over charge to Dr. W. McRae.

The post of Joint Director was held by Dr. W. H. Harrison up to 10th March, 1929, by Dr. W. McRae from 11th March to 11th April, and by Dr. F. J. F. Shaw from 12th April to the end of the year under report.

Staff. Dr. W. H. Harrison having proceeded on leave for seven months from 11th March, 1929, Dr. J. Sen was appointed to officiate as Imperial Agricultural Chemist, in addition to his own duties as Plant Biological Chemist.

During the absence of Mr. G. S. Henderson on leave for six months and two days from 5th April, 1929, Mr. Wynne Sayer, Secretary, Sugar Bureau, officiated as Imperial Agriculturist, in addition to his own duties.

On the retirement of Mr. A. Howard, C.I.E., on 8th December, 1928, Dr. F. J. F. Shaw was confirmed in the post of Imperial Economic Botanist.

Mr. T. Bainbrigge Fletcher resumed charge as Imperial Entomologist from Mr. P. V. Isaac on return from leave on 4th September, 1928.

Mr. N. V. Joshi was relieved of the current duties of the post of Imperial Agricultural Bacteriologist on 16th November, 1928, on the return of Mr. J. H. Walton from leave.

Consequent on the appointment of Dr. W. McRae as Agricultural Adviser to the Government of India, the services of Mr. J. F. Dastur, Mycologist to the Government of Central Provinces, were obtained to officiate as Imperial Mycologist, from 24th June, 1929.

Mr. Aga Muhammad Mustafa, Agronomist, remained throughout the year on deputation to the Administration of the North-West Frontier Province as Agricultural Officer.

II. RESEARCH.

The research work done by the Institute aims at establishing principles which can be put into general practice by provincial agencies. The more important work of the year under report is summarized below :—

Botanical Section. With an average yield of 1,968 lb. over 50 acres under private estate conditions, Pusa 52 has definitely established itself as the wheat for North Bihar, and its distribution has been taken up extensively by the local department. The new wheats under trial are Pusa 111, 112 and 113, which are selections with definite characters from natural crosses in Pusa 4, and Pusa 114, a bearded variant of Federation. A preliminary trial with the pure line strains of barley isolated has fixed B-4 as the highest yielder. Oat types B. S. 1 and 2 having proved smut-resistant and superior in yield to Pusa Farm oats in a field test as well, have been selected for distribution to local planters and to various Departments of Agriculture. The crossing of the famous American tobacco Adcock with the indigenous Pusa Type 28 has given a hybrid (No. 177) with a leaf which, when flue-cured, is superior both in colour and in burning and smoking qualities to that of Adcock itself. A large-scale trial with this hybrid has been arranged in the Guntur District where several acres will be grown in the coming season and cured under the direction of the Indian Leaf Tobacco Development Company. One of the types of pigeon-pea isolated has given indications of combining wilt-resistance with high yield. Efforts are also being made to evolve superior varieties of linseed, gram, lentils and chillies, either through selection or hybridization.

Chemical Section. Based on the observation that a rod of pure antimony dipped into moist soil develops an electric potential proportional to the p H value, a simple and portable apparatus has been designed for employment in the field. From the titration curves obtained, it is easy to calculate the amount of lime which must be added to an acre of soil in order to obtain neutrality or any required point of

acidity or alkalinity. Of the several methods employed in curing of tobacco on racks, the one of curing in the sun, but protecting the leaves from dew, has been found to give the best result in respect of colour, texture and paucity of volatile nicotine. A study of the factors contributing to the loss of potatoes during storage has shown that the phenomenon of rotting is accompanied by a decrease of albuminoid nitrogen and an increase of ammonical nitrogen almost to the same extent. The Plant Biological Chemist has undertaken an investigation into the occurrence of symbiotic nitrogen fixing organisms within the roots of the rice plant. The Physical Chemist continued to investigate the base capacity of the soil. A new method of dispersing soils for mechanical analysis has been worked out and a new percolating cylinder for measuring the permeability of soil to water has been devised.

Bacteriological Section. Estimations of the nitrogen content of several plots, carried out in some cases for two years and in others for three years, have not shown the very wide fluctuations noticed elsewhere by other workers. The importance of liming acid soils was clearly indicated in tests carried out to determine the nitrogen-fixing powers of some soils. Three to five times as much nitrogen was fixed by green algae in the months of June-October as in December-April. The reported favourable influence of metallic aluminium on nitrogen fixation could not be traced in Pusa soil or in liquid culture. The toxicity of sodium carbonate to nitrifying organisms has been found to be less than that indicated by the results of earlier workers, while no material difference has been noticed in the nitrifying capacity of ammonium chloride and ammonium sulphate. Observations made for a second year have confirmed that the keeping quality of the Pusa dairy milk is about twice as high from November to March as it is from April to September. Investigations are in progress to determine whether there is any characteristic seasonal variation in the types of colon bacillus occurring in milk.

Mycological Section. The record of pigeon-pea wilt in the manurial plots has again given indications that super-phosphate encourages the disease, that green manure discourages it, and that when both are applied they have an effect intermediate between the two applied separately. Roguing systematically carried on for three seasons at Pusa has reduced the incidence of mosaic disease in the two principal Coimbatore canes selected for distribution to such a small amount as to be eliminated as a possible controlling factor of tonnage. The percentage of affected clumps in Co. 210 was only 0.02 as against 2.5 in 1925-26; the respective figures for Co. 213 are 0.3 and 5-10. Co. 214 has throughout remained immune. A survey made to determine the presence of mosaic in various parts of the white sugar belt has revealed the presence of another disease of sugarcane which appears to be identical

with the Pokkah-bong disease of Java. So effective has spraying proved in the control of betle-vine wilt, which is causing a loss of several lakhs in the plantations of Bengal, that several spraying outfits have been purchased by growers living in the neighbourhood of experimental plots. Among other diseases under investigation are four of *Cinchona ledgeriana*, viz., Pink-disease, Bleeding disease and "Stem rust" seedling disease in Munsong and Seedling disease in Mungpoo.

Entomological Section Work on *Neomaskellia bergii* as a transmitter of mosaic in sugarcane has hitherto given negative results. The Braconid parasitic on the adult weevils of *Mylocerus 11-pustulatus* var. *maculosus* attacking cotton plants, previously referred to as *Loxoccephalus* sp., has been determined to be a new species of *Dinocampus*, and a technique for rearing it in captivity has been evolved. A study was made during the year of the lifehistory of an Aleyrodid (*Bemisia gossypiperda*, n. sp.) which was reported to have done considerable damage to cotton in the Punjab during the 1928 season. The results are embodied in Pusa Bulletin No. 196. The fruit pests in Baluchistan and the North-West Frontier Province also received attention during the year. A spraying fluid made up of locally available materials such as powdered soap-nut and country soap was effective in controlling the Green Aphis which causes a leaf-curl of peach leaves. The use of mercury, either in the form of free mercury or of mercury-tin amalgam, has proved so effective in preserving from insect pests grain stored in small receptacles for household purposes, that large-scale experiments have been undertaken. Work on the life-histories and distribution of Tabanidæ is being continued.

Agricultural Section. The permanent experiments being carried out in collaboration with other Sections of the Institute were continued. The sugarcane work mainly concentrated in New Area consists of varietal tests from the preliminary sorting-out stage to the mill trial in bulk. Experiments are also in progress to test the value of different fertilizers, as well as to determine the conditions in which cane can be sown with advantage in October instead of in February as is the practice in North Bihar. As the monsoon rainfall was defective in distribution, there was a heavy drop in the production of green fodder in the non-experimental area which forms a demonstration in mixed farming on a large scale. The reclaimed *dhab* area of 130 acres, in which two crops of berseem and early maize are raised by irrigation, however, helped in maintaining the dairy herd in excellent condition. In the pure Sahiwal herd, six cows gave over 5,600 lb. each in a lactation period of 304 days; among the half-bred progeny of rejected Sahiwal cows sired by either Ayrshire or Holstein bulls, the yields of seven cows ranged between 10,360 lb. and 8,200 lb. The average yield per cow per day for the year was 17.6 lb., as against 16.5 lb. in the previous year and 14.4

lb. in 1924-25. While the average percentage of cows in milk in the cross-bred herd was 69, in the pure herd it was only 51.

Imperial Dairy Expert. At Bangalore, in addition to a herd of Scindi cows, there are a number of heavy-yielding cows with European blood in varying proportions. The latter are now sired by Indian bulls of good milch pedigree with a view to producing a hardier strain less susceptible to disease. The same policy has been adopted at Wellington, where a pedigree herd of Ayrshire cattle is also being maintained to supply the acclimatized bulls required for crossing purposes. At Karnal, pure herds of Thar-Parkar and Hariana cattle and Murra buffaloes are being built up by selective breeding. A flock of Bikaner sheep has been collected during the year for similar treatment. The Creamery at Anand is being used for the manufacture of butter on a factory scale. It is being utilized, too, for experimental work in connection with the manufacture of ghee, condensed milk and casein and the treatment of new milk with a view to transporting to long distances. The Imperial Dairy Expert continued to give Provincial Departments of Agriculture and Co-operation, city municipal corporations and private individuals advice and assistance in technical matters connected with dairying and cattle-breeding. Among the important scheme supplied by him during the year may be mentioned those for the erection and equipment of modern milk factories for Darjeeling and Madras.

Physiological Chemist. Comparative tests of the values of typical Indian oil-cakes for milk production have shown that, weight for weight, linseed and groundnut cakes produce identical amounts of milk with the same fat content. Linseed cake, as compared with country coconut cake, produces more milk but the latter produces slightly richer milk. It has been definitely ascertained that wheat straw, when converted into silage, provides a palatable and a moderately succulent feed for the hot weather. The quantity of water required is about $2\frac{1}{2}$ times as much as that of straw. In experiments on the nutrition of growing animals, gram husk has been found to have a distinct positive value. The determination of the mineral constituents of pastures under different typical soil and climatic conditions has revealed that advancing maturity is associated with a decline in phosphorus, though lime does not generally decrease to the same extent. The physiological studies in progress have shown that the acid base balance of the animal system is directly influenced by hippuric acid excretion. The serious amounts eliminated in several cases indicate an unsuspected amount of potential benzoic acid in certain fodders. It, however, remains to be investigated whether growth would be seriously affected with certain fodders on account of the benzoic acid generated.

Government Sugarcane Expert. The bulk of the thin seedlings grown during the year were obtained by crossing Co. 213 with Co. 214 and

Co. 213 with Co. 281. The results of such large scale hybridization of parents of known characteristics, judged from the selections made, would appear to be satisfactory. The problem of replacing Co. 205 with a cane with its good points but without the defects of impure juice and late maturity promises to be tackled through inbreeding. The number of thick seedlings raised was considerably larger than in the two previous seasons. Out of 100,000 seedlings raised, 19,000 were transplanted to the second ground nursery, 1,048 were subsequently selected for chemical analysis, and 130 were finally chosen for further trial. The sucrose content of the majority of selected seedlings, particularly those of S. W. 111, ranged from 18.48 to 22.95 per cent.

Sugar Bureau. Being relieved of the actual work of growing cane for testing purposes, the Secretary of the Bureau is now able to devote more time to the extension of the area under selected canes. Demonstration work carried out in the Saran District of North Bihar, in co-operation with the local Department of Agriculture, has resulted in the establishment of Co. 210, Co. 213, and Co. 214 in the Marhowrah area. Co. 290 and Co. 287 promise to do well in North Darbhanga. Arrangements were made during the year for trials with Co. 281, which is so highly spoken of in Cuba and Florida, in the Central Provinces, Bihar and Orissa, and Burma. The Sugar Cable Service, conducted by the Bureau on a self-supporting basis, continues to receive the support of the trade.

III. TRAINING.

Agricultural Research Institute, Pusa. The two-year post-graduate course was completed during the year by Messrs. Sawan Mall (in Botany) and Ram Narain Singh (in Entomology).

Of the 26 candidates for admission to the new session commencing on 1st November, 1928, five were considered suitable by the Selection Committee, two being admitted for training in Mycology, two in Botany and one in Chemistry. On the recommendation of the Principal, Agricultural College, Nagpur, a scholar of the King Edward Memorial Society, Central Provinces and Berar, was also admitted subsequently to the course in Botany. Together with three admitted in the previous year (one each for Chemistry, Botany and Entomology), there were thus nine students undergoing the post-graduate course at the close of the year. An Entomological Assistant from the Central Provinces and an Assistant Professor of Agriculture in the Punjab Agricultural College were admitted to special one-year courses in Entomology and Botany, respectively. The student deputed by the Indian Central Cotton Committee for a one-year course in Entomology completed his training during the year under report. Four post-graduate students of the Imperial Institute of Animal Husbandry and Dairying

were given short courses at Pusa in estate management, cattle-breeding, plant diseases, etc.

Imperial Institute of Animal Husbandry and Dairying, Bangalore. Five post-graduate students completed their 15-month course during the year. There were six applicants for admission during the current session, of whom four were selected.

Ten students appeared for the Indian Dairy Diploma examination and six were declared successful. Six of the former number were fresh candidates from the Allahabad Agricultural Institute, while the remaining four were permitted to appear on a second occasion after a repeat course of six months at Bangalore.

Short courses in cattle-breeding and dairying were provided for nine students, and twelve Dairy Diploma students from the Allahabad Agricultural Institute also received technical instruction at the Bangalore and Karnal farms and the Anand Creamery.

Imperial Cane-Breeding Station, Coimbatore. Five students, including two from Mauritius, took advantage of the facilities for training in cane-breeding technique available at this station.

IV. PUBLICATIONS.

Twenty-two memoirs, 20 bulletins and four other publications were issued during the year, while 19 publications were in the press on 30th June, 1929. The publications issued dealt with subjects of general interest such as the production of cigarette tobacco by flue-curing, improved agricultural implements and machinery in use at Pusa, design for farm buildings, a method of increasing the manurial value of *mahua* cake, the improvement of grasses and grasslands, the composition of Indian feeding stuffs, the cultivation of lac, etc.

The Agricultural Journal of India, which is issued every two months, and *The Journal of the Central Bureau for Animal Husbandry and Dairying in India*, a quarterly, started in April, 1927, continued to maintain their popularity among the classes of readers for whom they are intended.

V. GENERAL ADMINISTRATION.

Buildings. The construction of a set of six clerks' quarters undertaken during 1927-28 was completed during the year under report.

Library. In addition to 400 periodicals and 1,575 books, bulletins, reports and pamphlets received in exchange, 231 periodicals and 610 volumes of new books, bulletins, reports, etc., were purchased during the year. Out of 2,823 publications issued on loan, 276 were sent to officers of the Provincial Departments of Agriculture.

Hospital. Medical relief was afforded to 284 in-patients and 9,297 out-patients in 1928, as against 238 and 8,733, respectively, in 1927.

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Of the 1,060 operations performed, 16 were "selected" ones. Among cases of the more important tropical diseases, 616 were of malaria, 168 of dysentery, 173 of Kala-azar, 13 of plague, 2 of cholera and 1 of leprosy.

The health of the residents on the Pusa estate, on the whole, was satisfactory, and there were no serious outbreaks of epidemic disease throughout the year.

VI. ACCOUNTS.

The total expenditure during the financial year ending 31st March, 1929, as shown below, was Rs. 7,88,502, as against Rs. 7,08,638 in the previous year.

	Rs.
General expenditure of the Institute, including the office of the Agricultural Adviser	2,64,285
Botanical Section	52,256
Chemical Section	1,05,408
Bacteriological Section	43,268
Mycological Section	47,723
Entomological Section	77,362
Agricultural Section	1,47,068
Sugar Bureau	30,807
Sugar Cable Service	20,325
	<hr/>
	7,88,502

The following were the principal items of expenditure met from the grant of Rs. 6,000 placed at the disposal of the Agricultural Adviser for expenditure on special agricultural experiments :—

	Rs.
Cost of seeds sent to the Karnal Farm for experiments	433
Cost of an Olpad thresher and of a Sabul plough supplied to the Ajmer-Merwara Administration for demonstration	119
Grant-in-aid to Mr. C. I. Parr, Manager, Harsinghpur Concern, for carrying out experiments on tobacco curing	900
Cost of fencing the lac area at Pusa	887
Cost of a Comptometer purchased for the Botanical Section at Pusa for biometrical calculations	1,688
Expenditure in connection with experiments on mosaic by the Imperial Mycologist	616

The receipts during the year amounted to Rs. 88,511 as detailed below :—

	Rs.
Fees from students	2,650
Sale of farm produce	10,315
Sale of milk, cattle, etc.	37,285
Subscriptions to the Sugar Cable Service	20,862
Other receipts	17,399
	<hr/>
TOTAL	88,511

VII. H. E. THE VICEROY'S VISIT.

Since the late Lord Curzon laid the corner-stone of the splendid building which houses the various laboratories of the Pusa Institute, it was honoured by a visit from His Excellency the Viceroy on a second occasion during the year under report. Lord Chelmsford's visit took place in 1919, and after a period of exactly 10 years, Lord Irwin, whose keen interest in the development of Indian agriculture is well known, visited the Institute on 4th January, 1929. His Excellency, who was accompanied by Lady Irwin and the Hon'ble Anne Wood, spent a busy day in inspecting the work being conducted in the laboratories and the field, and evinced much interest in all that he saw.

REPORT OF THE IMPERIAL ECONOMIC BOTANIST.

(F. J. F. SHAW, D.Sc., A.R.C.S., F.L.S.)

I. INTRODUCTION

Dr. Shaw held charge of the Section throughout the year. Mr. Howard retired from the Indian Agricultural Service on the 8th December, 1928, and Dr. Shaw was confirmed in the post of Imperial Economic Botanist with effect from that date. A sum of approximately Rs. 3,402 was realized from the sale of improved seeds and credited to Government during the financial year under review.

The increasing amount of teaching, and of reaserch work, which must accompany the teaching, has encroached considerably on the area of land which is available for the multiplication of pure seed of the Pusa varieties of crops. In order to maintain the supply of pure seeds for Provincial Departments of Agriculture, arrangements were made with the Imperial Agriculturist and with the Imperial Dairy Expert to carry out most of the seed multiplication on the Pusa Farm and on the Imperial Cattle Breeding Farm at Karnal. Owing to this assistance the seed supply was increased during the past year, but the work of supervising the operations at Karnal made very heavy demands on the staff of the Section and it will not be possible to continue these activities at Karnal without special provision of staff and equipment.

The replacement of all thatched roofs in the Section with corrugated iron was completed and a tank for water supply for the fire engine was constructed. Their Excellencies Lord and Lady Irwin inspected the Section on 4th January 1929.

Training. Mr. Mahbub Alam, M.Sc., remained in the Section as a voluntary research worker until 5th January 1929, when he was appointed to the post of Assistant Economic Botanist, Bihar and Orissa, and sent to Pusa for a further period of 2 months' training in the Botanical Section. Mr. Alam was chiefly occupied during his concluding months in the Section with a study of the inheritance of characters in gram, the results of which are summarised elsewhere in this report. This work on the genetics of the gram plant led to a study of the methods of computing linkage values from observed phenotypic frequencies in an F_2 population and a memoir on this subject (*Mem. Dept. Agri. India, Bot. Ser.*, Vol. XVIII, No. 1) by Mr. Alam has been published. Mr. Sawan Mal, a scholarship student from the Punjab Government, completed his course of training and was appointed to the post of Assistant to Millet Botanist, Punjab. In his second year at Pusa he commenced

a study of the unit species of cowpea (*Vigna catieng* Endl.) and was allowed to take the material and notes of this work to the Punjab for completion. Mr. R. B. Deshpande continued his course of instruction and was of material assistance in the investigations on wheat, chillies and sesamum. In collaboration with Chaudhury Ali Mohammad, he carried out an investigation of the root systems of the chilli types; the results are published in the *Agricultural Journal of India*. Chaudhury Ali Mohammad, Assistant Professor of Agriculture, Lyallpur, joined the Section in November 1928 for one year's training in oil-seed investigations for the post of Oil-seed Expert in the Punjab Department of Agriculture. He was chiefly employed on the research work on linseed, sesamum and safflower and collaborated in the work on chilli root systems mentioned above. He has also carried out an investigation on the influence of different manures on the growth, yield and oil content of linseed. Mr. P. D. Dixit, M.Sc., Lucknow University, Mr. R. Madhow Row, B.A., Madras University, and Mr. R. B. Ekbote, L.Ag. (Hons.), Nagpur Agricultural College, joined the Section in November 1928 for the full post-graduate course of instruction. They have been employed in the study of biometrical methods and have each been of material assistance in one or more of the investigations in progress in the Section.

Season and rainfall. The year 1928-29 was on the whole favourable, but some damage was done to the *kharif* crops by an exceptionally heavy fall of rain in the beginning of August. The following Tables show the total rainfall and the yields of crops in the Botanical Area in the year under review :—

Statement of rainfall in Botanical Section in 1928-29.

Month	Average for 20 years 1906-25	From 1st June 1928 to 31st May 1929	Difference
June 1928	8.30	3.40	—4.90
July	11.06	14.05	+2.99
August	14.61	24.60	+9.99
September	8.74	2.81	—5.93
October	1.32	6.10	+4.78
November	0.42	..	—0.42
December	0.07	0.14	+0.07
January 1929	0.22	1.27	+1.05
February	0.75	..	—0.75
March	0.40	0.75	+0.35
April	0.66	0.15	—0.51
May	1.59	0.42	—1.17
TOTAL	48.14	53.69	+5.55

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Statement showing the yields of crops in the Botanical Section in 1928-29.

Crop	Plot	Area in acre	OUTTURN OF GRAIN IN LB.		REMARKS
			Actual	Per acre	
Wheat—					
P. 111 . . .	Pentagonal . . .	1·00	1,574	1,574	
„ . . .	Barah 2 (10 plots) .	0·13	287	£2,208	
P. 4 . . .	Pentagonal . . .	0·98	1,284	£1,310	
„ . . .	Barah 2 (Triangular) .	0·22	523	2,377	
„ . . .	„ (10 plots) .	0·13	324	2,492	
P. 113 . . .	Pentagonal border (East)	0·1	203	2,030	
„ . . .	„ „ (West)	0·14	254	1,814	
P. 112 . . .	Riverbank West . .	0·74	1,660	2,243	
P. 12 . . .	Pentagonal . . .	1·02	1,523	1,493	
„ . . .	Barah 2 (10 plots) .	0·13	398	3,062	
P. 52 . . .	Riverbank East . .	0·76	1,837	2,417	
„ . . .	Barah 2 (10 plots) .	0·13	381	2,931	
P. 80-5 . . .	Musahar plots 1 and 2 .	0·44	760	1,727	
P. 101 . . .	Lawn plot 2 . . .	0·33	781	2,367	
P. 114 . . .	Pentagonal . . .	0·98	1,576	1,608	
Linseed—					
T. 12 . . .	Orchard 2B . . .	0·35	256	731	
T. 121 . . .	Barah 4 . . .	0·75	1,021	1,361	
T. 124 . . .	„ 1 . . .	1·1	793	721	
Russian Flax . . .	„ 1 . . .	0·25	101	404	
Gram—					
T. 26 . . .	Barah 3 . . .	0·1	121	1,210	
T. 17 . . .	Orchard 3A . . .	0·2	365	1,825	
„ . . .	Barah South Border .	0·5	525	1,050	
T. 25 . . .	N. T. G. 10 . . .	0·15	453	3,020	
„ . . .	„ 11 . . .	0·12	92	767	
T. 6 . . .	S. T. G. 9 . . .	0·18	164	1,022	
Safflower—					
T. 30 . . .	Orchard 3B . . .	0·42	537	1,279	
Chillies—					
T. 4 . . .	Orchard 5B . . .	0·1	563	5,630	Undried fruit.
T. 34 . . .	„ . . .	0·08	266	3,325	„
T. 41 . . .	„ . . .	0·12	763	6,358	„

Statement showing the yields of crops in the Botanical Section in 1928-29
—contd.

Crop	Plot	Area in acre	OUTTURN OF GRAIN IN LB.		REMARKS
			Actual	Per acre	
<i>Chillies—contd.</i>					
T. 51	Orchard 5 B	0.1	543	5,430	Undried fruit.
Culture Red 46 old .	„	0.08	528	6,600	„
„ Yellow 46 old	„	0.04	169	4,225	„
<i>Rahar—</i>					
A	Lawn plot 1	0.3	410	1,490	
B	N. T. G. 10	0.16	195	1,218	
C	„	0.16	141	881	
D	Lawn plot 3	0.34	563	1,656	
E	N. T. G. 10	0.32	434	1,356	
G	Lawn plot 1	0.15	109	1,327	
H	„	0.17	255	1,500	
K	„	0.15	213	1,420	
M	N. T. G. 10	0.16	208	1,300	
P	Lawn plot 1	0.15	181	1,207	
R	N. T. G. 10	0.16	236	1,475	
S	„	0.16	410	2,563	
T	Lawn plot 1	0.15	318	2,120	
107.	„	0.15	162	1,080	
117.	N. T. G. 10	0.16	137	862	
116.	„	0.16	153	956	
170.	Musahar plots	0.11	55	500	
166.	„	0.11	89	809	
American 1	„	0.11	26	236	
„ 2	„	0.11	1	9	
<i>Oats—</i>					
B. S. 2	Orchard 6B	1.44	4,145	2,878	
B. S. 1	„ 6A	1.57	3,733	2,378	
„	Musahars plots	3.00	6,082	2,027	
<i>Barley—</i>					
B-22	Orchard 1B part	0.24	564	2,350	
B-24	„ „	0.24	574	2,392	
B-4	Orchard 4B part	0.1	344	3,440	Seeds sown dry.
„	„ „	0.1	426	4,260	Seeds soaked in hot water before sowing.

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Statement showing the yields of crops in the Botanical Section in 1928-29
—concl'd.

Crop	Plot	Area in acre	OUTTURN OF GRAIN IN LB.		REMARKS
			Actual	Per acre	
<i>Barley—contd.</i>					
B-23	Orchard 4 B part . .	0.1	266	2,660	Seeds sown dry.
"	" "	0.1	283	2,830	Seeds soaked in hot water before sowing.
B-20	" "	0.1	252	2,520	Seeds sown dry.
"	" "	0.1	256	2,560	Seeds soaked in hot water before sowing.
<i>Tobacco—</i>					
Hybrid 142 . .	Orchard 4A	0.25	162	648	Outturn of flue- cured leaf.
140	"	0.25	139	556	Do.
198	"	0.25	185	740	Do.
205	"	0.25	142	568	Do.
184	"	0.25	169	676	Do.
153	"	0.25	169	676	Do.
177	"	0.25	149	596	Do.
Adcock	"	0.25	209	836	Do.
Culture 185 . .	N. T. G. 3	0.017	..	522	Do.
83	"	0.017	..	768	Do.
167	"	0.017	..	30	Do.
147	"	0.017	..	321	Do.
198	"	0.017	..	553	Do.
177K	"	0.017	..	615	Do.
177L	"	0.017	..	615	Do.
63	"	0.017	..	246	Do.
216	"	0.017	..	594	Do.
166	"	0.017	..	522	Do.
55	"	0.017	..	799	Do.
171	"	0.017	..	444	Do.
101	"	0.017	..	492	Do.
130	"	0.017	..	307	Do.
Bouri	"	0.017	..	492	Do.
Cenden	"	0.017	..	645	Do.
Karebaglain . .	"	0.017	..	492	Do.
Lanka	"	0.017	..	321	Do.
Sindine	"	0.017	..	690	Do.
Bhengi	"	0.017	..	246	Do.
Kawnia	"	0.017	..	707	Do.

As has been mentioned above, the bulk of the seed multiplication was carried out on the Pusa Farm and at Karnal and a statement of the yields obtained at these places and on various Government farms and private estates to whom seed had been supplied is appended below :—

Statement showing the outturns of improved varieties from the Botanical Section grown on Pusa Farm and at Karnal.

Place	Field	Crop	Area in acre	OUTTURN IN LB.		
				Actual	Per acre	
Pusa Farm	H. Jhilli	Wheat— Pusa 4	10.0	10,379	1,038	
		" 12	10.0	13,841	1,384	
		" 52	10.0	14,489	1,449	
		Brickfield II	" 52	8.0	13,202	1,650
		Punjab Field	" 111.	2.0	2,072	1,036
		Rahar— Bhograsan	" A "	17.0	..	1,176
	Punjab	" G "	1.0	..	1,950	
		Chandman	" B "	17.0	..	972
		Oats— Brickfield II	B. S. 1	7.0	9,775	1,397
	" "	B. S. 2	7.0	10,254	1,465	
	Gohri	B. S. 1	10.0	20,055	2,005	
	"	B. S. 2	10.0	18,354	1,835	
	Imperial Cattle Breeding Farm, Karnal.	Wheat— P. 4	49.0	78,884	1,610
			"	0.1	249	2,490
			P. 111	0.1	249	2,490
Gram— T. 6		0.14	130	929		
		T. 17	0.15	118	787	
		T. 25	3.0	3,116	1,039	
		Linseed— T. 121	1.0	1,127	1,127	
T. 124		1.0	1,066	1,066		

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Statement showing the outturns of improved varieties from the Botanical Section grown on various Government Farms and private estates to whom seed had been supplied.

	Place	Crop	Area in acres	Outturn per acre lb.	REMARKS
		<i>Wheat—</i>			
Manager, Gangowlie Estate.	Alampur . . .	P. 52 . .	50	1,968	
Manager, Dhol Indigo Concern.	Dholi . . .	P. 12 . .	12.5	1,574	
	„ . . .	P. 4 . .	14.1	1,378	
Deputy Director of Agriculture, North Bihar Range.	Sepaya . . .	P. 12 . .	1.3	1,164	
	„ . . .	P. 4 . .	1.2	1,427	
	„ . . .	P. 52 . .	15.0	1,164	
	„ . . .	P. 80-5 . .	5.0	1,722	
	Sewan Farm . .	P. 80-5 . .	..	1,701	
	„ „ . . .	P. 52 . .	..	1,126	
	Darbhangha . .	P. 52 . .	4.25	1,312	
Deputy Director of Agriculture, Chota Nagpur Range.	Netarhat . . .	P. 12 . .	..	984	
	„ . . .	P. 80-5 . .	..	820	
	Chiankl . . .	P. 52 . .	..	820	
	„ . . .	P. 80-5 . .	..	820	
		<i>Gram—</i>			
Deputy Director of Agriculture, Rohilkhand.	Shahjahanpur . .	T. 17 . .	..	1,417	Both varieties suffered from wilt.
	„ . . .	T. 25 . .	..	1,242	
Superintendent of Agriculture, iSurma Valley.	Sylhet . . .	T. 25 . .	..	902	Gave the highest outturn.
Deputy Director of Agriculture, North Bihar Range.	Sepaya . . .	T. 17 . .	7.5	435	Mixed with linseed.
	Sewan . . .	T. 17 . .	..	730	
	Darbhangha . .	T. 17 . .	} 2.6 {	771	Grown mixed.
		<i>Linseed—</i>			
		T. 12 . .		180	
		<i>Gram—</i>			
Deputy Director of Agriculture, Chota Nagpur.	Kanke . . .	T. 17 . .	..	1,722	
		<i>Oats—</i>			
Deputy Director of Agriculture, North Bihar.	Sepaya . . .	B. S. 1 . .	1	2,312	
		<i>Linseed—</i>			
	Sepaya . . .	T. 12 . .	4.1	287	Mixed with gram.
		T. 124 . .	1.8	205	„ „ „
		T. 121 . .	0.1	713	

Statement showing the outturns of improved varieties from the Botanical Section grown on various Government Farms and private estates to whom seed had been supplied.—contd.

—	Place	Crop	Area in acres	Outturn per acre lb.	REMARKS
Deputy Director of Agriculture, North Bihar— <i>contd.</i>	Sepaya . . .	<i>Rahar—</i>			
		P . . .	0.09	1,591	
		R . . .	0.09	1,582	
		M . . .	0.09	1,483	
		D . . .	0.09	1,553	
		B . . .	0.09	1,378	
	Sepaya . . . Sewan . . .	<i>Tobacco—</i>			
		T. 28 . .	2.0	1,722	Leaf.
		T. 28 . .	..	1,278	

II. INVESTIGATIONS.

Wheat (*Triticum vulgare*, L.). Good yields of wheat from the Pusa types were obtained both in the Botanical Area and on estates and farms outside Pusa. The wheat Pusa 52 again gave excellent results yielding 1,650 lb. per acre over 8 acres on the Pusa Farm and 2,417 lb. per acre on 0.76 acre in the Botanical Section. This wheat also did very well on the Gangowlie Indigo Estate where an average yield of 1,968 lb. was obtained over 50 acres. Pusa 52 may be considered to have become established as the wheat for North Bihar and its distribution is being taken up extensively by the local Department of Agriculture. It may in later years find a rival in Pusa 80-5 which has done well (1,722 lb. per acre) on the Government Farm, Sepaya.

The new wheats Pusa 111 and Pusa 114 gave yields of 1,574 and 1,608 lb. per acre, respectively. Two other new wheats Pusa 112 and Pusa 113 were also tried and gave yields of 2,030 lb. and 2,243 lb. per acre, respectively. These yields may be compared with the yields of Pusa 4 and of Pusa 12 in the same field, which were 1,574 and 1,493 lb. per acre, respectively. Pusa 112 and Pusa 113 are both selections from natural crosses in Pusa 4. Pusa 112 is later in maturity than Pusa 4 and is a taller plant, beardless with felted glumes. Pusa 113 differs from Pusa 112 in having the heads slightly tipped. Both these wheats will be tested in the coming season at Pusa and trials have also been arranged on Government Farms in the United Provinces. It must be remembered that these yields in the Botanical Area are only the result of trials on small areas; reliable results can only be obtained in such cases from the replication of plots and the application of statistical tests.

The incidence of rust was much less severe in the year under review than in the previous season. This is reflected in the bushel weights of the various wheats in the two seasons :—

Wheat	WEIGHTS PER BUSHEL IN LB.			
	1925-26	1926-27	1927-28	1928-29
Pusa 4	64.9	63.0	63.25	63.9
Pusa 12	61.5	65.0	56.3	63.3
Pusa 52	65.5	63.0	62.17	64.0
Pusa 80-5	65.0	56.5	55.9	65.3
Pusa 90	64.25	64.0	60.16	..

The fourth hybrid generation of the crosses between Pusa 4 and Federation and Pusa 52 and Federation was grown at Pusa and at Karnal; those cultures which were selected for trial at Karnal were somewhat later in maturity than is required for Bihar. Among 78 cultures which were grown at Pusa, 32 were rejected and 46 were selected for further trial next season and at Karnal from a trial of 40 cultures 17 were selected; some of these cultures appear to be very promising types. A few exceptionally late maturing cultures were tried at the Government Farm, Taru Jabba, N.-W.F. Province.

The following approximate quantities of wheat seed were distributed to Departments of Agriculture and private growers during the year under report :—

1. *Grown in the Botanical Section—*

	md.
Pusa 4	12½
Pusa 111	20½
Pusa 112	4
Pusa 113	3½
Pusa 114	6½
Pusa 52	10½
Pusa 12	3
Pusa 80-5	5
Pusa 101	4

2. *Grown on Pusa Farm—*

	md.
Pusa 4	118½
Pusa 12	111
Pusa 52	206½

3. *Grown at Karnal—*

	md.
Pusa 4	662

BARLEY (*Hordeum vulgare*, L.). Barley constitutes one of the main cereal crops of Northern India and a number of pure line strains have been isolated. A tentative classification of the different forms has been completed and will soon be written up for publication. The more promising strains have undergone a preliminary varietal trial and B-4 maintains its position as the highest yielder. Some seed of this type was distributed in the year under review to neighbouring planters who were impressed with the stand and yield of the crop. Three types have also been sent to the Department of Agriculture, United Provinces, for trial on their Government farms.

OATS (*Avena sterilis*, L.). As outlined in the Annual Report for 1927-28, a further trial of B.S. Type 1 and B.S. Type 2 was undertaken this year on a large scale on the Pusa Farm, with the help of the Imperial Agriculturist. The following results were obtained with these selections against Pusa Farm oat :—

Variety	Plot	Area in acre	OUTTURN IN LB.	
			Actual	Per acre
B. S. Type 1 . .	Brickfield II . .	7.0	9,775	1,397
B. S. Type 2 . .	„ „ . .	7.0	10,254	1,465
Pusa Farm . .	„ „ . .	6.0	7,960	1,327
B. S. Type 1 . .	Gohri	10.0	20,055	2,005
B. S. Type 2 . .	„	10.0	18,354	1,835
Pusa Farm . .	„	10.0	16,788	1,679

Both these plots were flooded for a long time during the rains and are not of very high fertility. The difference is in favour of the B.S. types in every case and is greater in the fields (Gohri) of higher fertility. The B.S. oats, Types 1 and 2, have yielded 2,378 lb. and 2,878 lb., respectively in the Botanical Area (page 13).

The B.S. selections can now be called high yielding and in addition possess the property of smut-resistance. High yields and disease resistance in these two selections of oats will undoubtedly give them a ready market. About 61 maunds of seed oats has been distributed this year to local planters and to various departments of agriculture.

Hybridization :—The F_2 generation of a cross between Abundance and B. S. 4 has been studied this year.

A study of the F_3 generation of two crosses between Scotch Potato oats and two Pusa types confirms the observations and interpretations made in the F_2 .

The Indian parent has a distinct articulation at the base of the lower grain (*Sterilis* character) which is absent in the exotic parent (*Sativa* character). The F_2 and F_3 segregations show a ratio of 3 : 1 *sativa* to *sterilis* type of base, which suggests a single factor difference. Similarly segregations for basal hairs are on a monohybrid ratio, while those of awns show a 9 : 7 ratio. Linkage conditions have been observed between factors for certain characters. The inheritance of certain quantitative characters has also been studied. These include the inheritance of the number of spikelets per panicle, the number of tillers per plant, the number of days taken to flower, height of plants, and the average length and breadth of leaves. Some of these have been explained on the multiple factor hypothesis.

A number of freaks have been observed in the spikelets of oats and an article on the subject has been published in the *Agricultural Journal of India*.

Field observations have indicated that the Pusa types of oats possess a considerable measure of resistance to smut disease. A preliminary experiment has confirmed this indication and the question will be the subject of a detailed investigation next year.

TOBACCO (*Nicotiana Tabacum* Linn.). During the season under report the work with this crop consisted in the testing of some of the hybrids from the cross between Adcock and Type 28. The capacity of the barn, and the shortness of the curing season, limits the amount of work of this nature which can be carried out in a single season, and in all seven hybrids were tested in comparison with Adcock. All these types yellowed well in the barn, but one, No. 177, gave a leaf of which the colour was markedly superior to that of any other hybrid or of Adcock itself. A preliminary burning and smoking test was carried out in February 1929 in collaboration with officials of the Indian Leaf Tobacco Development Company, and although such a test of immature leaf can only give an indication of the possibilities of the tobacco, the results were eminently satisfactory, No. 177 being pronounced superior to Adcock and to all other types under trial. As was explained in the last annual report on this subject, the burning and smoking qualities of a leaf cannot be adequately judged until the leaf has been about a year in store. About 80 lb. of the leaf of No. 177 is in store at Pusa and will be tested on a large scale next year. The yielding power of this tobacco will also be tested during the coming season and a trial has been arranged in the Guntur District where several acres will be grown and cured under the direction of the Indian Leaf Tobacco Development Company.

It may now be considered as definitely established that tobacco can be flue-cured in India to a colour which is suitable for cigarette manufacture. On a commercial scale it is found to be more profitable to

use a larger barn with nearly double the cubic capacity of that in use in the Botanical Section. This necessitates putting two furnaces and a double set of flue pipes into the barn, but the amount of leaf produced by a barn in the course of a season is increased in a ratio greater than the increase in the working expenses of the larger barn. The large barn therefore results in lower curing costs per lb. of leaf. Flue-curing experiments with Adcock tobacco were carried out on a neighbouring indigo estate where a barn has been built. Unfortunately an extraordinary distribution of the rainfall, which was quite local, almost ruined the crop for flue-curing purposes.

Among the hybrids which have been raised at Pusa, a number of types are unsuitable for flue-curing but may prove of use for local consumption. These types generally possess a coarse heavy leaf and give a high yield per acre. A number of these have been grown and the leaf has been ground-cured; comparison with the local varieties will be made when the leaf is properly matured.

LINSEED (*Linum usitatissimum*, Linn.). The economic object of the investigation on this crop is to obtain a linseed which will combine the bold seed with high oil content, which characterises the types of Peninsular India, with the erect vegetative habit and shallow root system of the types which are adapted to growth in the Gangetic alluvium. From the F_4 generation of the 8 original crosses, 74 pure cultures have been selected and a number of these appear to possess the desired characteristics.

RAHAR (*Cajanus indicus*, Spreng.). The isolation of the unit species in this crop is now completed and the results are being written up for publication. The number of distinct types obtained reaches to 107, showing very great variation in height, habit, time of maturity, flower colour, pod colour and shape, and size, colour and shape of seed. From a taxonomic standpoint, the flower colour and the characters of seed and pod appear to furnish the most reliable basis for the separation of the unit species, while from an economic standpoint, the height, habit, and time of maturity are of the first importance to the agriculturist. The habit ranges from a straggling bushy growth to an erect growth resembling a poplar tree. This latter is a desirable quality as it allows of the passage of implements for that interculture which is so necessary if the maximum yield is to be secured. The time of maturity is, of course, an important consideration in selecting a type to suit a particular locality; early maturing types do not do well in Pusa.

The flowers of different types vary in the depth of the yellow colour in the petals and in the amount and distribution of the red colour in the standard and wings. The red colour may be diffused over the back of the standard or restricted to lines radiating from the base of the standard; it may, in the former case, merely produce reddish patches

on the petal or form a heavy red, covering the whole of the back of the standard and completely masking the yellow colour. The pods may be straight or "beaded", in this latter case there are well marked constrictions in the pod between the seeds. The colour of pods is green in the unripe stage, but in many types black and red markings are developed which may be so extensive as to cover the whole surface of the pod. Seeds may be round or lens-shaped and range in colour from silver-white and fawn through brown and red to purple. The ground colour of the seed appears to be either silver-white or fawn and the other colours are present as markings which in some cases cover the whole seed surface and completely obscure the ground colour.

A cross between an erect type with pale yellow flowers and a spreading type with yellow flowers having a diffused red colour on the back of the standard was made in the previous season and the F_1 generation was grown in the year under review. The erect habit appeared to be dominant to the spreading habit and the diffused red colour was recessive to the absence of red colour; in another cross, however, the presence of red colour in lines on the back of the standard proved dominant. In the characters of the pod "green with markings" proved dominant to simple green and the "beaded" character was dominant to the straight.

The investigation on the isolation of a wilt resistant type of *rahar*, which is being carried out in collaboration with the Imperial Mycologist, will be completed during the coming season. A high degree of resistance has been developed in the course of the selection; it is a fortunate circumstance that the type in which wilt resistance exists has given indications of being also a high yielding type. Other things being equal, this would of course be expected in a type which is not liable to loss from disease. The F_1 generation of a cross between the wilt resistant type and a non-resistant type was grown and the F_2 generation is being grown this year both in infected land and in non-infected land. A comparison of the phenotypes which survive in the infected field with those which occur in the non-infected field will, it is hoped, throw further light on the correlation of morphological characters with the property of resistance. During the past season, in addition to the cross just mentioned, the F_1 generation of another cross, between the same non-resistant type and a type which possesses a considerable degree of resistance and is morphologically almost indistinguishable from the wilt resistant selection, was grown. The F_1 generation of both crosses was grown in an infected field and there was a marked difference in the incidence of disease in the two progenies, that from the wilt resistant parent showing a much lower death rate from disease than that from the type which resembled it so closely. This suggests that the correlation between morphological characters and resistance is possibly less

close than was suggested by the observations of previous years on the mortality of the two types.

The yields of some of the new pure types are shown (page 13) and are generally better than in the previous year owing to the more favourable season. Three types were tried on the Pusa Farm and the best yield was obtained from Type "G," which gave 1,950 lb. per acre; this type is that which resembles the wilt resistant selection in morphological features and which also possesses a considerable measure of resistance itself. Some of the types were also tried at the Government Farm, Sepaya and the results are given at page 17. Two new types "S" and "T" have given very good returns in the Botanical Area in the past season and will be tried on the Farm on a large scale this year.

GRAM (*Cicer arietinum*, L.). The isolation of unit species in this crop was completed and 61 new types have been obtained, with the 25 original types there are now 86 distinct varieties of this crop. Some of the new types show promise of being heavy yielders and yield tests will be necessary in the future. One of the new types, Type 86, appeared as a mutation in Type 24 in 1927-28. This appears to be a case of gigantism as the plant and all its organs show a great increase in size over any other type. The origin of this type was the sudden appearance of 3 plants in a culture of Type 24 in 1927-28, but unfortunately only one of these plants gave fertile seed. This seed was sown in the following year, 1928-29, and bred true to the new type, at the same time the mutation again appeared in the parent culture. If possible, a cytological comparison of the mutant and its parent will be carried out. The description and classification of the new types is being written up for publication.

The F_4 generation of the cross between Type 2 and Type 18 was grown and some cultures of the F_3 generation were repeated. The observations on F_2 and F_3 had established that the inheritance of colour in the seed is due to the segregation and interaction of 4 factors, a new seed colour, orange, appearing as the recessive. Owing to the small population available in F_2 , the recessive phenotype was not obtained in this generation but appeared in F_3 , the scheme of inheritance being finally worked out from a close study of the segregation in a large number of cultures in that generation. In F_4 generation all plants with orange seed colour in F_3 bred true for this character, thus confirming the deductions from previous observations. Orange and not white is therefore the fundamental colour in gram seeds. This was not known prior to this investigation and all forms with orange seeds will be additions to the existing types. The study of the F_4 generation has shown that, although fawn seeds have always been considered as associated with white flower colour, fawn seeded plants can split in later generations throwing fawn, white, red and orange seeded plants, the flower colour

remaining always white. Thus a number of cultures with red seeds and white flowers have been fixed; except for these cases red seed colour is correlated with red flower colour and white, fawn and orange seeds are correlated with white flower colour. The selections in the F_4 generation of this cross have this year been made with an economic object from high yielding plants with desirable seed characters.

The F_3 generation of the cross between Type 1 and Type 25 was also grown and observations on vegetative colour, seed colour and seed shape, etc., were made. The size of leaflets, petals, pods and seeds were also noted. It is interesting to note that the vegetative colour of the stem is an index to the genotypic condition of the flower colour. In flower colour, the homo- and hetero-zygous condition cannot be distinguished by observation on the flower itself, but plants, that are hetero-zygous for pink colour of the flower, show only a limited amount of red colour in stem and leaves, while those that are homo-zygous show a deep red vegetative colour extending all over the plant. This character is especially useful in making selections as it becomes possible to select at once a plant which will breed true for flower colour.

Most of the F_2 plants (1927-28) which were noted to possess much red colour have given progenies in F_3 , all of which bear pink flowers; while those F_2 plants which possessed only scanty red colour in the vegetative parts have given progenies that vary in flower colour, giving pink and white flowers in 3:1 ratio. The segregation of vegetative colour can thus be expressed as 1:2:1, *i.e.*, 1 with much red, 2 with medium red and 1 with no red (*i.e.*, green). The F_2 generation of this cross was grown again during the year under review and the segregation of vegetative colour has been again noted and found to be as follows:—

Segregation of vegetative colour in F_2 generation.

Year	Nature of cross	STEM AND LEAF COLOUR		
		Much red	Medium red	No red
1927-28 . . .	1 × 25 . .	39	90	42
	25 × 1 . .	59	134	49
	TOTAL .	98	224	91
1928-29 . . .	1 × 25 . .	76	139	62
	25 × 1 . .	60	151	62
	TOTAL .	136	290	124
Total observed frequencies . . .		234	514	215
Expected frequencies . . .		240.75	481.50	240.75
Observed ratio . . .		0.97	:2.13	:0.90
Theoretical ratio . . .		1	:2	:1
		<div style="display: flex; justify-content: space-around; align-items: center;"> Pink flowers. White flowers, </div>		

On the basis of the observations made in the F_2 generation of 1927-28, it was suggested in the last annual report that the flower colour is dependent on 3 independent factors, one of which determines the presence or absence of red colour and the remaining two act as quantitative factors and determine the amount of green colour. The results of the F_3 generation in 1928-29, however, do not conform to this. On the above theory four-fifth of the F_2 plants bearing greenish red or greenish white flowers must throw reds or whites respectively in the F_3 generation ; but actually we did not get a single greenish culture throwing plants with pure red or pure white flowers. This definitely shows that the presence or absence of green colour is also dependent on a single factor difference ; white being dominant over green and the recessive green colour breeding true. This monohybrid theory only partly explains the F_3 observations. So far as the presence or absence of green colour is concerned, the theory is correct, but how are we to account for the variation in green colour which has been definitely observed in F_2 plants of this cross ? This variation in green colour is, from the leathery, full green petals of one of the parents, to the papery, very slightly green condition (likely to be mistaken for a pure white) noted in the F_2 and F_3 progenies. The difference between the two extremes is so marked that it cannot be ignored and the monohybrid theory does not explain this. However, the occurrence of intermediate conditions suggests that the qualitative factor possesses some quantitative effect also and that the two act independently. The qualitative factor determines only the presence or absence of green colour, while the quantitative factor or factors determine the amount of green colour.

The seed colour is found to be as complex in this cross as in the previous cross. It is determined by at least three pairs of factors, which, by segregation and recombination, give rise to several classes of seed-colour. The observed frequencies of the various seed-colours noted in F_3 are given as follows :—

Gram Cross.

(Type 1 \times Type 25.)

Segregation of seed-colour in F_3 .

	27 Brown	9 Yellow brown	9 Red brown	9 Fawn	3 White	3 Red	3 Fawnish orange	1 Orange
Observed frequencies .	174	66	53	51	18	17	8	5
Theoretical frequencies	165.375	55.125	55.125	55.125	18.375	18.375	18.375	6.125

In this cross again the factors determining the colour and the shape of the seeds appear to be linked with one another, but some cases of cross-over occur; the exact nature of this linkage is not yet worked out. The linkage of pink flower-colour with brown and red seeds and that of white flower-colour with fawn, white and orange seeds, is perfect in this cross: not a single case of cross-over has been noted. (Cf. in the Type 2 \times Type 18 cross a number of cross-over seeds were found.) Most of the observations on the inheritance of these characters are completed and the results are now being compiled and will be published when the F_4 generation of the second cross (Type 1 \times Type 25) has been studied.

Together with the study of qualitative character, a large amount of data has been collected on various quantitative characters, such as size of leaflets, petals, pods and seeds, single plant yields, percentage of 1-, 2-, or more-seeded pods, etc. The interrelationship of these quantitative characters with each other as well as their relationship with other qualitative characters is also under investigation. The tabulation and interpretation of these results will take some time before it can be put in the form of a paper.

The complicated nature of the inheritance of "green colour" in the petals of Type 1 suggested its independent study by making a new cross between type 1 (with green petals) and Type 2 (with pure white petals). The F_1 generation of this cross was raised this year and the white colour is dominant over green as was expected. Another cross was made between Type 1 and one of the types that bear 2 flowers in each axil. The F_1 generation of this cross has also been raised.

LENTILS (*Ervum lens*, Linn.). Sixty-six types of lentils have been isolated and classified in this Section and a memoir on this subject published during the year. A number of promising types have undergone a preliminary varietal test and will be subjected to larger field trials in the next season.

A study of the inheritance of certain characters in three crosses has been made. Thus in the inheritance of flower colour a very good 3 : 1 ratio has been obtained in a cross between Type 25 and Type 17 where the flower colour of the parents is white and violet respectively, the F_2 frequencies being :—

	Violet	Light violet	White
Observed frequencies	34	69	32
Theoretical frequencies	33.75	67.5	33.75
Theoretical ratio	1 :	2 :	1

Similarly in a cross between Type 25 \times Type 5-A, where the colour of the flower of the parents respectively is white and violet colour on the veins only, the segregation is :—

—	Violet	Light violet	White
Observed frequencies	54	111	65
Theoretical frequencies	57.5	115	57.5
Theoretical ratio	1 :	2 :	1

An interesting case of inheritance of flower colour has been furnished by the cross Type 47 \times Type 25 in which the flower colour of both the parents is white and the F_1 and F_2 generations have shown a development of violet colour in the flowers. The F_2 segregation in this is :—

—	Violet	Light violet	White
Observed frequencies	43	107	87

which does not provide a good 3 : 1 or a 9 : 7 ratio. The correct interpretation of this will probably be available when the F_3 generation is studied.

In the cross, Type 47 \times Type 25, a study of the inheritance of habit has shown that spreading habit is dominant over erect habit, as is shown by the F_2 frequencies below :—

—	Spreading	Erect
Observed frequencies	170	57
Theoretical frequencies	170.25	56.75
Theoretical ratio	3 :	1

CHILLIES (*Capsicum annum*, Linn. and *C. frutescens*, Linn.). A memoir containing the description of 52 types of chillies was published in the past year and the root systems of all the types were studied during the year under report. The heaviest yielding types proved to be those having a vigorous fibrous root system near the surface of the soil. A paper on this subject has been published in the *Agricultural Journal of India*. Several new types were obtained during the year and one of these is of interest as it possesses yellow anthers, all the 52 types previously described having blue anthers.

Four of the types were selected for yield tests (pages 12-13). Type 41 gave the highest yield, but its fruits are thicker than those of the other three types and it is not likely to be popular. Type 4 gave the second highest yield but it is a thick round fruit which is generally used for pickling and is not much in demand for daily consumption. Type 51 was close to Type 4 in yield and is a fruit which will prove popular; it is probably the best type to recommend for cultivators. Type 34 was the lowest in yield but its fruits also are of a desirable type.

A study of the inheritance of characters in chillies was commenced with a cross between Type 3 and Type 29; this investigation is chiefly used for the training of students in Mendelian phenomena. These two types belong to distinct varieties, "*nigrum*" and "*acuminata pendula*," of *C. annuum*, and have very definite contrasting characters. In Type 3 the colour of the ripe fruit is red and in Type 29 it is orange; in the F_1 red is dominant. The fruit of Type 3 is globular and that of Type 29 is elongated; in F_1 the elongated form is dominant. Similarly, the pendent fruit habit of Type 29 is dominant in F_1 to the erect habit of Type 3.

PATWA (*Hibiscus cannabinus*, Linn., and *H. Sabdariffa*, Linn.). In 1927 some seed of *Calopogonium mucunoides* Desv. was obtained from Java and in the crop which was grown from this seed a stray plant of an unknown type of *Hibiscus* occurred. This plant grew to a considerable height with a straight almost unbranched stem and appeared to possess the habit of *H. cannabinus*, L., with some morphological characters of *H. Sabdariffa*, L. At the Royal Botanic Garden, Calcutta and at Kew, to both of which authorities specimens were referred, the plant was placed in *H. Sabdariffa*, L. and this identification was subsequently confirmed from Java. The four original types of *H. Sabdariffa*, L., described by the Howards, are quite useless for fibre purposes as their habit is branched and bushy. The new type may prove of considerable utility as it seems to be immune to the curious disease which has affected *H. cannabinus*, L. for some years past at Pusa. This disease, up to the present, has never appeared on any of the types of *H. Sabdariffa*, L. A description of the new type is being published.

Miscellaneous.

A card index of important papers on crop plants is being maintained in the Botanical Section. A list of papers dealing with recent investigations on important Indian crops has been compiled and sent in for publication as a Pusa Bulletin. This list, it is hoped, will provide a means of ready reference to scientific workers in India many of whom have no easy access to any good libraries.

A description of types of safflower by Khan Sahib Abdur Rahman Khan is also being published.

III. PUBLICATIONS AND PROGRAMME.

Publications.

1. SHAW, F. J. F. . . . Summary of the Progress of Research in Agricultural Botany for the year ending 31st March 1929, for inclusion in the Report of the Privy Council.
2. SHAW, F. J. F. . . . The Production of Cigarette Tobacco in India, *Capital*, Industrial Suppl., dated the 13th December 1928.
3. SHAW, F. J. F., and . . . List of publications on the Botany of
RAKHAL DAS BOSE. . . Indian Crops. *Agri. Res. Inst., Pusa Bulletin* No. 202.
4. KHAN SAHIB ABDUR . . . Studies in Indian Oil-Seeds, No. 3. *Carthamus tinctorius*, Linn. The Types of
RAHMAN KHAN. . . Safflower. *Mem. Dept. Agri. India, Bot. Ser.*, Vol. XVIII, No. 3.
5. KHAN SAHIB ABDUR . . . Pollination and Fruit Formation in *Litchi*
RAHMAN KHAN. . . (*Nephelium Litchi*, Camb.), *Agri. Jour. India*, Vol. XXIV, 1929, 183-187.
6. BOSE, R. D. . . . The Indian Oat and the Error in its Identification. *Agri. Jour. India*, Vol. XXIV, 1929, 169-176.
7. BOSE, R. D. . . . Some Freaks in Oat Spikelets. *Agri. Jour. India*, Vol. XXIV, 1929.
8. ALAM, M. . . . The Calculation of Linkage Values. *Mem. Dept. Agri. India, Bot. Ser.*, Vol. XVIII, No. 1, 1929.
9. CHOUDHRY ALI MOHAM- . . . Studies in Indian Chillies. 2. The Root
MAD, and . . . Systems. *Agri. Jour. India*, Vol. XXIV,
DESHPANDE, R. B. . . . 1929.

Programme for 1929-30.

Investigations will be continued on the lines indicated in this report on the following crops:—wheat, barley, oats, maize, tobacco, chillies, pulses, hemp, gram, linseeds, *rahar*, peas, etc. Experiments in the curing of tobacco and the inheritance of resistance to wilt disease in *rahar* will be continued. The training of students will continue as in previous years.

REPORT OF THE IMPERIAL AGRICULTURAL CHEMIST.

(J. SEN, M.A., PH. D.)

I. ADMINISTRATION.

Dr. W. H. Harrison held charge of the Section till 8th March, 1929, when he proceeded on 7 months' leave. Dr. J. Sen, Plant Biological Chemist, held charge of the Section, in addition to his own duties, for the remaining period.

Mr. P. B. Sanyal officiated as First Assistant, from 29th April to 6th July, 1929, during the absence on leave of Mr. J. N. Mukerji.

II. EDUCATION.

Mr. P. N. Vridhachalam, B.A., from the Travancore State, who was admitted to the post-graduate course in November, 1927, is continuing his studies. Mr. J. N. Chakravarty, M.Sc., was admitted to the post-graduate course on 16th November, 1928.

III. METEOROLOGY AND DRAIN-GAUGES.

The usual meteorological and drain-gauge records were maintained. In this connection the crops from the gauges and 95 samples of drainage waters were examined.

IV. GENERAL ANALYTICAL WORK AND ASSISTANCE GIVEN TO OTHER SECTIONS.

A. The following samples were analysed and reported upon :—

Soils	6
Manures	18
Oilseeds	115
Sugar.	2
Sugarcane	186
Sugar-beet	4
Milk	2,933
Water	1
Miscellaneous	3
Total	3,268

A sample of soil was received from the Rewa State. The sample of water was sent by the Executive Engineer, Baluchistan, and the four samples of sugar-beet were analysed at the request of the Agricultural Officer, North-West Frontier Province.

B. The following assistance was rendered to other Sections :—

Agricultural Section. Fifteen samples of manures, 177 samples of sugarcane, a sample of kerosine oil and 2,933 samples of milk were analysed.

Botanical Section. One hundred and fifteen samples of oilseeds and a sample of tobacco washing were examined.

Mycological Section. A sample of manure and 8 samples of sugarcane were examined.

Sugar Bureau. Two samples of sugar were analysed.

Entomological Section. A sample of bees' wax was sent to this Section for opinion as to its suitability for use as comb-foundation. On examination there were obtained indications of a probably heavy adulteration with some saponifiable foreign substance.

C. *Method of Analysis examined.* Magliano's modification of the Gerber method of estimating milk fat was examined. The results obtained by the two methods agree closely, but Magliano's method requires more time to carry it through. It offers no advantage over Gerber's method except when a centrifuge is not available.

V. RESEARCH.

1. *Soil acidity.* For several years a study has been made by Dr. Harrison of various metallic electrodes and their applicability to the determination of pH values, the object being to obtain a robust and reliable method suitable for field work. Several electrodes, such as molybdenum and tungsten, appeared to be promising, but the only one which gave uniformly concordant and reliable results over extended periods was antimony. Attention was therefore concentrated upon this electrode and the first part of his investigations has just been published as a Memoir of the department.

The work of most of the previous workers has dealt with potentiometric determinations made in solutions or suspensions which have been kept agitated or stirred. Dr. Harrison's earlier investigations showed that, although quick and sharp equilibria were obtained in buffer solutions under these conditions, very good readings were also obtained when the liquids were at rest. As the latter procedure eliminated cumbersome apparatus difficult of employment under field conditions, the present work has been developed mainly under unstirred conditions.

The readings obtained in unstirred buffer solutions are higher than those obtained in stirred solutions, an observation which is in agreement with that recently made by Snyder. This difference is probably due to a slow persistent drift in the case of unstirred solutions, but, if the point of equilibrium is taken as that when two consecutive half minute readings agree and the equation connecting potential and pH is

calculated from these readings, then pH determinations can be made on unknown solutions with an accuracy more than sufficient for all practical purposes. Because of this slow drift, it is also essential that the antimony electrode should be standardized by means of the instruments with which it is to be employed.

One of the main difficulties encountered in determining the pH value of a soil lies in the fact that the same soil may give very different values according to the method adopted in preparing the soil solution or emulsion. Thus the value given by a soil suspension may be very different from the value obtained after the suspension has been allowed to settle, or clarified by centrifugalizing, or filtered. In the present series of experiments with the antimony electrode, fairly uniform results were obtained under these different conditions with alkaline and neutral soils, but very variable values were obtained with acid soils and particularly with those of a lateritic character. The difficulty was finally solved by the observation that by merely dipping the antimony electrode into the moist soil, sharp satisfactory and reproducible readings were obtained which gave excellent agreement with the values obtained in soil suspensions by the hydrogen electrode. Based on this observation, a simple apparatus has been designed for employment in the field. Besides being easily portable, the apparatus possesses a further advantage inasmuch as in carrying out pH determinations with its help it is not necessary to submit soil samples to manipulative processes.

2. *Lime requirements of soils.* The robustness and ease of application of the antimony electrode makes it eminently suited to the determination of the lime requirements of a soil. Equal amounts of a sample of soil are weighed out into separate beakers and to each is added distilled water containing increasing additions of lime water, and the whole is well stirred and allowed to stand for half an hour. At the end of this time, the pH value of each mixture is determined and plotted against the equivalent amount of lime added. From the resulting curve it is easy to calculate the amount of lime which must be added to an acre of soil in order to obtain neutrality, or any other point of acidity or alkalinity, which may be desired.

3. *Curing of tobacco.* Experiments on this subject have been continued by Mr. Mukerji. As tobacco (whole plant) cured on racks had been found to be liable to attacks of mildew, it was decided to work this season with the leaves only, removing all stems. The adoption of this procedure made it possible to work, at their proper stages of ripeness separately, with the upper and the lower leaves, which latter of course mature earlier.

A consideration of the previous seasons' tests led to attention being confined to growing three varieties, viz., American Adecock, Pusa Type 28 and country variety Surujmukhi.

The following methods of curing were tried :—

1. Curing on ground, by the ordinary country method.
2. Curing on racks in the sun all through (*i.e.*, exposed to the sun and night dew).
3. Curing on racks in the sun, but protected from dews after dusk.
4. Curing on racks in the sun, unprotected from dew for first three days, after which the leaves are cured in sun protected from dew for about 10 days and finally cured in shade.
5. Curing on racks in the shade all through.

In April last the cured samples were taken to the Indian Tobacco Leaf Development Company, Dalsingsarai, for their expert opinion. Adcock samples cured by methods 3 and 4 were, as in previous years, declared the best of the whole lot. Pusa Type 28 cured on racks by methods 3 and 4, as well as Adcock and Pusa Type 28 cured on racks under shade (method 5), were the next best suitable for cigarette making. Adcock and Pusa Type 28 cured on racks all through in the sun, unprotected from dew (method 2), and the country variety Surajmukhi cured on racks by four different processes (methods 2 to 5) were the third in order. Surajmukhi, though good as regards texture, was lower in position owing to its colour being dark. All the three varieties cured on ground were declared unsuitable for cigarette manufacture.

Besides the above five different methods, a trial was given to the rapid curing of the varieties Adcock and Pusa Type 28 at a fairly high temperature through the provision of special ovens in the room in which the plants were hung on racks. The idea underlying this was to replace the so-called flue-curing process by a more convenient process which could be availed of by ordinary cultivators. The tobacco cures alright but in order to ensure success by this method a good deal of precaution and constant watch are necessary ; moreover, the method fails in case of tobacco with thick and heavy leaves, which invariably take ununiform colour when cured by this process. This defect has been observed in the flue-curing process as well.

The examination of these tobaccos in their uncured stage has shown as demonstrated in last year's tests that the country varieties generally contain more nicotine than the American ones and that the upper leaves in all the varieties are invariably richer both in nicotine and starch than the lower ones. It is interesting to note that the samples which have been declared by the experts as the best suitable for cigarette making contain *the least amount of nicotine*, and that tobaccos declared as the last in the grade for cigarette making contain *the most*. Tobaccos cured on ground, which have been declared as unsuitable for cigarette manufacture, of course, contain a still higher nicotine content. Garner, in the United States of America, has shown that the undesirable sharpness and pungency noticeable in the smoke of certain types of tobacco

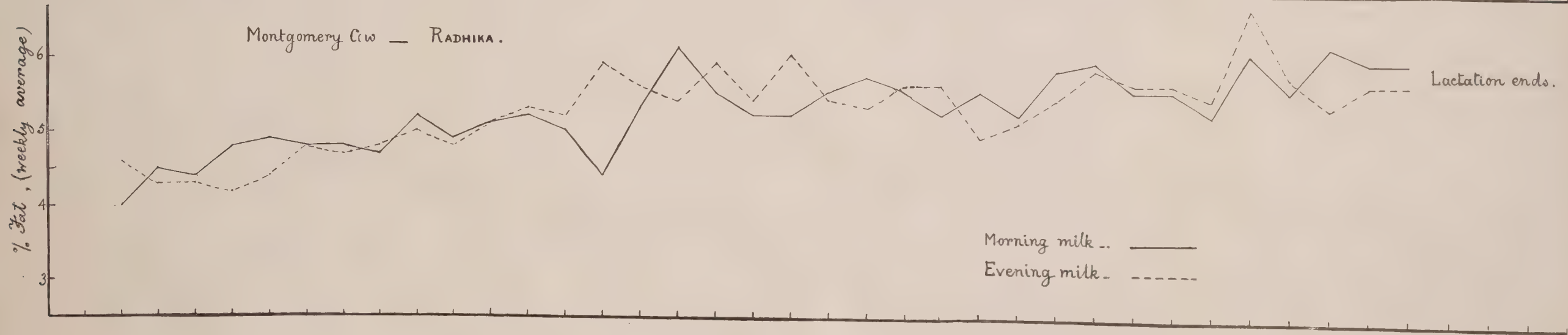
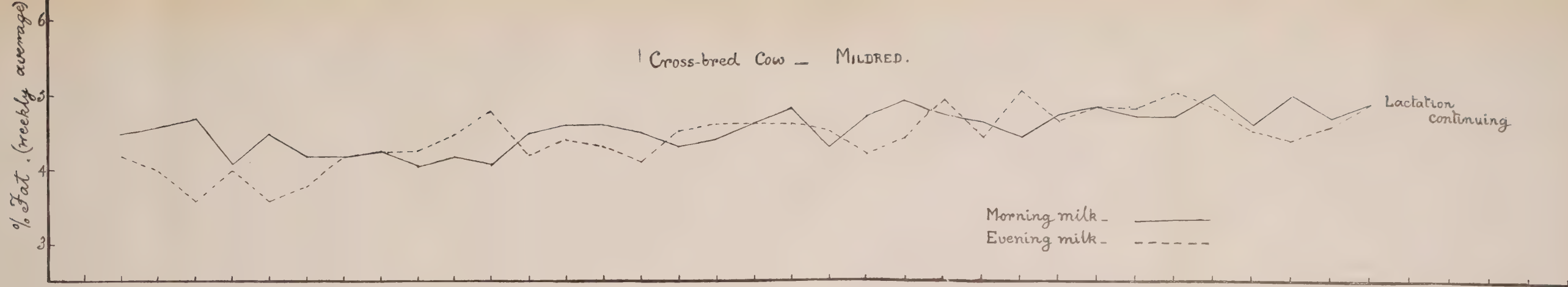
is due almost entirely to the presence of the volatile form of nicotine which acts as if it were in the free state. It has been definitely shown in Mr. Mukerji's previous investigations that rack curing has the effect of reducing the nicotine content and specially that of the *volatile nicotine*, and the present experiments show that of the several methods employed in curing of tobacco *on racks*, the one of curing in the sun but protecting the leaves from dew gives the best results in respect of colour, texture and paucity of volatile nicotine, an excess of which would produce an undesirable sharpness or pungency.

4. *Storage of potatoes.* In North Bihar there occurs a very considerable loss of potatoes in the course of 3 or 4 months after the harvest. Mr. Sanyal has undertaken a study of the factors concerned. For this purpose a white variety of potatoes (Italian) was obtained from the local market and, after the tubers had undergone a preliminary process of fumigation with carbon bisulphide, they were graded in different sizes and subjected to different treatments for storage. An analysis of the potatoes has been carried out in the beginning, since when they are being periodically examined and further analyses are being undertaken from time to time. Records of temperature of the air and of that prevailing in the stored potatoes are being maintained.

It is too early to come to any definite conclusions, but some of the interesting facts observed may be mentioned here. The experiment was begun at the end of March, when the mean atmospheric temperature in shade was about 82°F. The tubers were not affected during the first month and a half of their storage although there were spells of rises in the temperature in the second and fourth weeks of April. Rotting, however, ensued when the mean temperature rose rapidly and persisted to be near about 90°F. for three weeks from the middle of May. Comparing stored potatoes of the same size, it has been noticed that the losses are heavier when the mean atmospheric temperature was 90°F. (e.g., during the period of 3 weeks, 18th May to 8th June) than when it was 85°·9 (3 weeks, 9th June to 30th June). The symptoms noticed in the rotted potatoes are softening of the tissue, watery exudation from the tubers and the development of a foul smell. It is found that small-sized potatoes suffer this loss to a less extent than those of a bigger size.

The total and ammoniacal nitrogen contents of the sound potatoes has been found to remain practically constant for the period (three months). There is a slight diminution in albuminoid nitrogen with the progress of time.

Comparing sound and rotted potatoes, it has been noted that the phenomenon of rotting is accompanied by a decrease of albuminoid nitrogen and an increase of ammoniacal nitrogen almost to the same extent.



5. *Manurial applications and crop composition.* During the course of analysis of crops growing on plots which are being subjected to systematic applications of different manures for a long time, it was noticed that there was a variation in the composition of the plants. The changes in the soil conditions effected by the continuous application of manures are reflected in the composition of the plants growing on the soils. As an instance, the following table of analysis obtained by Mr. Ukil may be quoted.

Composition of oats straw, 1927-28.

	Manure applied			
	Plot 1 <i>Nil</i>	Plot 7 Ammonium sulphate	Plot 8 Super- phosphate	Plot 9 Potassium sulphate
CaO, per cent.	0.90	1.02	0.81	0.82
Fe ₂ O ₃ per cent.	0.100	0.107	0.065	0.056
Al ₂ O ₃ per cent.	0.280	0.416	0.087	0.082
Ratio $\frac{Al_2O_3}{Fe_2O_3}$	2.80	3.88	1.34	1.45
pH of the soil	8.46	8.52	8.33	8.17

The work is being continued.

6. *Variations in the fat content of milk of selected cows.* Milk of four Montgomery cows and four cross-bred cows was examined twice daily during the year. The percentage of fat (average 5.4) in the milk of Montgomery cows is generally higher than that in the milk of cross-bred cows (average 4.3), and the range of variation from the beginning of the lactation period to the end of it is wider in the case of Montgomery cows than that in the case of cross-bred cows. The fat percentage increases with the progress of lactation. The rise in fat percentage is, however, not steady but is marked with occasional falls. The graph on the opposite page will illustrate the points mentioned above.

7. *Soil moisture movements.* In a country like India where the amount and distribution of the monsoon rainfall mean so much to the agriculturist, the study of water movements in the soil is of particular importance. The results obtained by Mr. A. T. Sën, post-graduate student, in the investigation of rise of moisture in soils under field conditions are shortly to be published. It is interesting to note that the data published by Major Leather two decades ago receive a strong

confirmation from the figures now obtained. All these results support the important deduction that during dry weather water moves upwards from a limited depth only.

8. *Investigations conducted by the Plant Biological Chemist.*

1. *Bacterial Association as a possible factor in the nitrogen assimilation of rice plants.* Some work has been done by the Plant Biological Chemist on the occurrence of nitrogen-fixing organisms in the roots of rice. Several samples of plants were collected from the fields of cultivators from different areas outside Pusa. The contents of their roots were examined under the microscope, taking every care to prevent any possibility of their contamination from outside sources. It was noticed that certain bacteria were present inside the roots. Culture solutions containing sugar and minerals but no nitrogen in any form were next inoculated with the contents of the roots. Slimy bacterial growths were noticed on incubation. Experiments showed that anaerobic conditions favoured their development. Microscopic examination of the growths revealed the presence of characteristic capsulated bacteria.

Through the courtesy of the authorities of the Agricultural College, Coimbatore, an examination was made of five strains of paddy growing on their farm. The presence of organisms was noticed in the roots of all these, and inoculations of four of the samples in liquid culture were brought over to Pusa for further investigation. These also yielded positive results on incubation.

The development of bacterial growth in the solutions, which contained no nitrogen, clearly indicated an assimilation of nitrogen from the gaseous atmosphere. Actual analyses confirmed this deduction, as a definite, though small, fixation of nitrogen (upto 5 mg. in 250 c.c. culture solution) was observed. It is of interest to compare these figures with results obtained in the case of nodule bacteria of legumes. Although these latter organisms discharge their functions very efficiently when growing in their natural environments within the root nodules, their development and activity when inoculated on substrates ordinarily used in the laboratory are often very slight. Several investigators could not discover any nitrogen assimilation. Those who succeeded in getting positive results usually obtained low figures (2-3 mg. nitrogen per 100 c.c.) like the ones obtained in the case of the organisms present in rice.

It will not be out of place to draw attention to a very important point of difference between the cultural conditions prevailing in typical rice lands and those in fields growing leguminous crops. Except in the case of upland varieties, the rice cultivators' field practice is to try to maintain a stand of water on the ground from the time of transplantation onwards. The rice roots have thus, for the greater part of their

life, to develop under anaerobic conditions. With legumes, on the other hand, the growth of roots takes place under aerobic conditions. The phenomena of the growth and development of the nitrogen-fixing symbiotic bacteria present in rice roots are thus expected to be somewhat different from those of organisms associated with roots of legumes.

The demonstration of an occurrence of those bacteria throws new light on the problem of nitrogen nutrition of rice and opens out many interesting lines of study.

Pure cultures are being isolated, the investigation of which, as well as of the crude cultures and of their relationship to the plant, is being continued.

2. *Removal of plant food by crops.* An investigation is being carried out in the manurial plots of the Imperial Agricultural Chemist in the North Pungarbi Field. There are six plots—each $\frac{1}{80}$ of an acre in area—three of these being unmanured and three receiving applications of (a) green manure, (b) superphosphate, and (c) green manure + superphosphate respectively. These were laid out in 1923, since when they have every season, except in 1927-28, been treated with the requisite manures and a *rabi* crop (oats) grown on them, fallow conditions being maintained during *kharif*. In 1927-28 wheat was grown without any manure. This season the plots received the usual applications of manure and oats were again grown.

The crop was sown on 23rd October 1928. Representative samples of plants were collected for analysis on three different dates: 8th December 1928 (early stage), 29th January (flowering stage) and 19th March, 1929 (harvest time). From the last samples (mature crop) grains and straw (including chaff) were separately analysed, while in the two earlier samples the whole plants were subjected to analysis.

The results of the analysis of the final crop are given below.

Composition of oats (at harvest), N. Pungarbi, 1928-29.

Plot No.	Treatment	Average andry wt. of plant gm.	Component	Moisture per cent.	Organic nitrogen per cent.	Ash per cent.	Soluble mineral matter per cent.	Potash (K ₂ O) per cent.	Phosphoric acid (P ₂ O ₅) per cent.
1	No manure .	7.69	Grain . Straw and Chaff .	6.08 5.19	1.59 0.35	2.62 5.59	1.45 4.87	0.43 1.92	0.412 0.054
2	Green manure .	10.18	Grain . Straw and Chaff .	5.87 4.42	1.71 0.44	2.64 6.68	1.45 5.02	0.45 1.78	0.379 0.061
3	Superphosphate .	8.51	Grain . Straw and Chaff .	6.14 7.34	1.42 0.33	3.05 7.70	1.58 5.64	0.36 1.70	0.413 0.066
4	Green manure and superphosphate.	17.36	Grain . Straw and Chaff .	7.24 7.60	1.24 0.26	2.80 6.41	1.64 4.86	0.30 1.56	0.564 0.076
5	No manure .	8.36	Grain . Straw and Chaff .	8.23 5.48	1.45 0.28	3.04 8.43	1.51 6.02	0.35 1.77	0.497 0.099
6	No manure .	9.96	Grain . Straw and Chaff .	6.63 4.34	1.40 0.31	3.15 7.38	1.78 5.37	0.39 1.87	0.545 0.099

It will be seen that among the above crops, the one from the green manure plot has yielded grains richest in nitrogen and potash but poorest in phosphoric acid. Where, however, green manure has been supplemented with superphosphate, the results have been reversed, the grains being there richest in phosphoric acid but poorest in nitrogen and potash. Plant growth has been heaviest on the green manure + superphosphate plot.

An examination of the soils of these plots is now being conducted.

3. *Miscellaneous.* The Agricultural Adviser received a communication from the Indigo Association about conducting trials of a method of indigo manufacture which was claimed to possess advantages over the ordinary process. Tests were carried out in this laboratory with indigo plants obtained through the courtesy of the Dholi Indigo Concern and of the Imperial Agricultural Bacteriologist. The various factors involved in the new process were studied, but the results indicated that the suggested method was not a satisfactory one.

Infected and healthy stems of two types of *rahar* (*Cajanus indicus*) were analysed for the Imperial Mycologist in connection with his studies on the wilt disease of *rahar*.

Four samples of fresh grass and one sample of hay sent by the Agricultural Adviser were analysed.

9. Investigations conducted by the Physical Chemist.

1. *Studies in soil colloids.* (a) *Base exchange and soil acidity.* It was reported last year that the base neutralising power of a soil could be divided into three components, corresponding approximately to the dissociation of three hydrogen ions in a tribasic acid. These were designated as H_1 , H_2 and H_3 . In this connection field experiments on liming were carried out at the Monipur Farm, Dacca (Bengal), to study the toxic limits of surface active hydrogen according to the above stages of reaction.

It appeared that the lime requirement of the soil could be determined by taking H_1 stage of reaction as the toxic limit, but it varied slightly with the type of manure. Lime without any manure gave very poor return on these soils. Lime and farmyard manure appeared to be the best combination.

The lime requirement of soils can be determined as follows.—The soil is measured in a capsule of 20 c.c. capacity and shaken with about 100 c.c. water for few minutes in a conical flask. Excess of $CaSO_4$ is added; also 5-10 drops of 1 per cent. Brom Thymol Blue (dissolved in 50 per cent. alcohol). It is then titrated with $\frac{N}{30}$ lime solution till a bluish green colour is obtained on leaving the suspension for a couple of minutes. Each c.c. of alkali used represents one maund of lime per acre (up to 6" depth).

(b) *Factors influencing the dispersion of soil colloids in water.* Variations in soil tilth are chiefly brought about by soil colloids particularly with reference to their flocculated or deflocculated condition. It appears that the nature of the exchangeable ion has a profound influence on the state of dispersion of the soil; for instance, the presence of sodium in the clay complex is associated with very high dispersion and results, on drying, in the hard impervious condition of the soil well known in alkali districts. Calcium, on the other hand, brings the soil to a good workable condition. However, Na-saturated soil does not lose its high degree of dispersion when the Na is displaced by Ca, provided the clay is not allowed to become dry. Only in redispersion after drying do differences, due to the nature and valence of cation become evident. The importance of this result in the practical reclamation of alkali soils by the application of gypsum is indicated. In this connection a dispersion method has been developed which indicates the degree of alkalization of a soil which should prove useful in surveying alkali tracts. A full discussion of the above and other related phenomenon will be given in a paper being prepared for publication.

(c) *Flocculation of soil colloids.* A study of the phenomenon of flocculation has been made with particular reference to the nature of exchangeable bases. It appears that soils rich in exchangeable Na require a very larger amount of the flocculating agent for coagulation than those containing Ca. The phenomenon of flocculation is attended with marked changes in the rate of percolation, etc.; based on which a method of determining gypsum requirement of alkali soils has been developed and is being tested with soils from a number of alkali tracts.

(d) *Method of estimating soil colloids.* From a critical examination of the various methods of estimating soil colloids, it appeared that most of them are influenced by the nature of the exchangeable bases in the soil. Attention is specially drawn to the so-called ammonia adsorption which is shown to be a chemical action pure and simple and therefore to be incapable of being used for estimating soil colloids, though it could be used for finding the saturation capacity of a fully unsaturated soil.

It is suggested that hygroscopicity of a soil should be determined by bringing it into equilibrium with an atmosphere of 70 per cent. humidity, the soil in equilibrium with 10 per cent. humidity being considered as dry. Besides other advantages, this method facilitates interpolation as the interval between 10 per cent. and 70 per cent. humidity is represented by a straight line on the vapour pressure curve for all soils.

(e) *Method of determining saturation capacity and degree of saturation of soils.* The state of saturation of the soil (V) is defined as the ratio of the amount of absorptively bound bases in the soil (S) to the amount of bases the soil is capable of binding (T), both values being

expressed in equivalents. Thus $V = \frac{100 S}{T}$. As the result of a critical examination of the methods of determining (T) and (S), a new method of determining (V) has been suggested. The method along with data on a number of soils will be given in a paper to be sent up for publication shortly.

2. *A new method of dispersing soils for mechanical analysis.* Based on the easy dispersibility of soil saturated with Nations, a new method of dispersing soils for mechanical analysis has been worked on. A full discussion of the method with comparative data on 47 soils forms the subject matter of a memoir which is in the press. A short description of the method is also given in a note in the *Agricultural Journal of India*. The following is a brief outline of the same.

10-20 gm. of soil are left with 1 to 2 hundred c.c. of N. NaCl for about half an hour with occasional stirring. The suspension is then filtered and washed with about 500 c.c. of the same solution on filter paper. It is finally washed with a few c.c. of $\frac{N}{10}$ solution and when the whole of it has been drained off, the remaining quantity is displaced with 10-20 c.c. of water. The suspension is then transferred to a stout beaker with 3-5 hundred c.c. of water, and $\frac{N}{10}$ NaOH gradually run in till it is alkaline to phenolphthalein (used as an external indicator). The suspension is then mechanically shaken for one hour or left for 5-6 hours with occasional hand shaking.

3. *A new percolating cylinder.* A new percolating cylinder for measuring permeability of soil to water has been devised. It is particularly suited to the measurement of a factor related to soil texture. A full description of the cylinder and its uses is given in an article accepted for publication in the *Agricultural Journal of India*.

4. *Physico-chemical measurements on Indian soils.* Investigations are being conducted to determine physico-chemical methods best suited to the study of Indian soils, and for the purpose of characterising the most important features of the soils of this country; over sixty soils have been collected from different provinces.

VI. PROGRAMME OF WORK FOR 1929-30.

A. Imperial Agricultural Chemist.

1. Effect of manurial combinations on the quality of cane juice and the gur produced therefrom.
2. Composition of crops as affected by manurial treatment.
3. Variations in the composition of milk.
4. Study of the changes occurring in tobacco leaf under various methods of curing.

5. The employment of the antimony electrode for the determination of the pH value of soils and its application to field conditions.

6. A study of the methods for determining the lime requirements of soil.

B. Plant Biological Chemist.

1. To study the influence of organic matter on the soil.
2. To study the question of nitrogen recuperation in Indian soils.
3. To investigate the fixation of nitrogen by plants.

C. Physical Chemist.

1. Continuation of studies in soil colloids.
2. Physico-chemical aspects of reclaiming alkali soils.
3. Standardization of physico-chemical method best suited to the study of Indian soils.

VII. PUBLICATIONS.

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| HARRISON, W. H., and
VRIDHACHALAM, P. N. | The Application of the Antimony Electrode to the Determination of the pH value and lime requirement of Soils. <i>Mem. Dept. Agri. India, Chem. Ser.</i> , Vol. X, No. 4. |
| PURI, A. N. | A new Method of Dispersing Soils for Mechanical Analysis. <i>Mem. Dept. Agri. India, Chem. Ser.</i> , Vol. X, No. 8. (<i>In the press.</i>) |
| " " | A new percolating cylinder and some of its uses. <i>Agri. Jour. India</i> , Vol. XXIV, Pt. 6. |
| " " | The hypothesis of unfree water in soils. <i>Agri. Jour. India</i> . Vol. XXIV, Pt. 6. |
| " " | A new method of dispersing soils for mechanical analysis. <i>Agri. Jour. India</i> , Vol. XXIV, Part IV, 1929. (<i>In the press.</i>) |
| PURI, A. N., and VEN-
KATRAMAN, T. S. | An apparatus for testing rind hardness in Sugarcane. <i>Proceedings Sugar Technologists' Association of India</i> . (1928.) |
| SANYAL, P. B. | The Detection of Adulteration of Butter and Ghee with animal fat. <i>Jour. Cent. Bureau for Animal Husbandry and Dairying in India</i> , Vol. II, Part III. |
| " " | Adulteration of Butter and Ghee with Animal fat and Vegetable ghee and its detection. <i>Mem. Dept. Agri. India, Chem. Ser.</i> , Vol. X, No. 3. |

- SEN, A. T. . . . A Study of the Capillary Rise of Soil Moisture under Field Conditions. *Mem. Dept. Agri. India, Chem. Ser.*, Vol. X, No. 9. (*In the press.*)
- SEN, J. . . . Is Bacterial Association a Factor in Nitrogen Assimilation by Rice Plants? *Agri. Jour. India*, Vol. XXIV, Part IV, July 1929.
- ” . . . Report of the Progress of Agricultural Chemistry in India for the year 1928-29, for the Committee of the Privy Council for Scientific and Industrial Research, London.

REPORT OF THE IMPERIAL AGRICULTURAL
BACTERIOLOGIST.

(J. H. WALTON, M.A., M.Sc.)

I. ADMINISTRATION.

Mr. N. V. Joshi was in charge of the Section till 15th November, 1928, when I returned from leave and held charge of the Section for rest of the year.

Mr. N. V. Joshi, First Assistant, was on leave on average pay for 30 days from 1st March, 1929. Mr. C. S. Ram Ayyar, First Assistant, Industrial Branch, acted in place of Mr. N. V. Joshi, and Mr. Harihar Prasad, Laboratory Assistant, acted in place of Mr. C. S. Ram Ayyar.

Mr. S. V. Desai, Gazetted Assistant, was granted leave on average pay for 1 month and 11 days combined with study leave for 12 months with effect from 20th August, 1928. Mr. N. D. Vyas, Laboratory Assistant, acted in place of Mr. S. V. Desai.

II. TRAINING.

There were no admissions of post-graduate students during the year.

III. SOIL BIOLOGY.

Nitrogen in field soils. The observations on the nitrogen content of field soils, in the Punjab Field Permanent Manurial Plots and the experimental plots of the Section, were concluded after having been continued for two years and for three years respectively. The very wide fluctuations found by other investigators in India did not occur here.

Estimations of the nitrogen content of eight plots of the irrigated land in the *dhab* area on the farm showed only very small differences in the nitrogen figures for April 1926 and April 1929, though fairly wide fluctuation had occurred between these dates. Nitrification in three of the plots, each containing about 100 mg. nitrogen per 100 gm. soil, was estimated. In eight weeks six milligrams of nitrate nitrogen were recovered.

Nitrogen fixation. Four further series of experiments to test the ability of green algæ to fix atmospheric nitrogen were carried out during the year. An incubation period of two months was used in each experiment. From three to five times as much nitrogen was fixed in the months June—October as in the months December—April.

The nitrogen-fixing powers of some soils were tested, and the importance of liming acid soils was clearly indicated.

The favourable influence of metallic aluminium on nitrogen fixation, reported by certain other workers, could not be traced in Pusa soil or in liquid cultures.

Nitrification. Certain results obtained when nitrification was carried on in the presence of sodium carbonate indicated the need for further investigations on the influence of this alkali salt on nitrifications, and the toxicity of sodium carbonate to nitrifying organisms in soil has been found to be less than that indicated by the results of earlier workers.

Sodium carbonate in different concentrations from 0.05 to 0.5 per cent. was added to Pusa soil and the results showed that nitrification of both cake and ammonium sulphate was stimulated by doses up to 0.2 per cent. Doses greater than this inhibited nitrification for eight weeks, but after ten weeks it started in the soil with 0.3 and 0.4 per cent.

In Kalol and Chinsurah soils, additions of sodium carbonate up to 0.2 per cent. stimulated nitrification. Higher concentrations up to 0.5 per cent. retarded it for a few weeks, after which this effect disappeared. Nitrification was suppressed by concentrations above 0.5 per cent.

Sodium sulphate in quantities up to 0.5 per cent. had no influence on nitrification in Pusa soil.

Sodium chloride, 1 per cent., hindered the nitrification of cake, but 0.2 per cent. had little influence on the nitrification of ammonium sulphate. 0.6 per cent. was toxic till the eighth weeks of incubation.

Ammonium chloride having been put on the market as a commercial fertiliser, its nitrification was compared with that of ammonium sulphate in different soils, and no material differences were found.

After treatment with dilute mineral acid for three weeks, calcium cyanamide nitrified readily in Pusa soil—over 50 per cent. in four weeks. Further observations on its nitrification in acid soils and the effect of liming were carried on.

Nitrification and lime requirement of soils. The lime requirements of two acid soils from Neterhat in Chota Nagpur were determined by different chemical methods, and the nitrification of cake and ammonium sulphate estimated in these soils, with various additions of bases in the forms of calcium oxide, hydroxide or carbonate. Maximum nitrification was obtained by the addition of lime in double the quantity given as the lime requirement of the soil by the Hutchinson and MacLennan method. Linseed plants grown in pots of the soil with different quantities of lime required, for healthy growth, twice the quantity of lime indicated as the lime requirement of the soil by this method. Nitrification was stimulated by the addition of cultures of active nitrifiers. Nitrification of calcium cyanamide in Karimganj soil was stimulated

by additions of lime or calcium carbonate applied in quantities up to that indicated as the lime requirement by the Hutchinson and MacLennan method; though nitrification in the untreated soil started earlier, the amount of nitrate produced was surpassed in the eighth week by that in the soil with calcium carbonate, and in the tenth week by that in the soil with calcium oxide.

In Karimganj soil, additions of 0.1, 0.3 and 0.5 per cent. calcium carbonate increased the production of nitrate nitrogen in sixteen weeks from 8.4 mg. per 100 gm. soil to 12.0, 16.8 and 19.2 mg. respectively.

Nitrification of sulphate of ammonia, which did not occur in unlimed soil from Dacca, was encouraged to start by the addition of doses of calcium carbonate of from 0.025 to 0.5 per cent. The greatest dose had the most stimulating effect.

Phosphate solubilization. None of the insoluble phosphate of three types of rock phosphate, Trichinopoli nodule, radiophos and Singhbhum phosphate, was turned into a soluble form in 12 weeks by cultures of nitrifying organisms, although 34 per cent. of that in tricalcium phosphate was made soluble in that time.

No further improvement in the method of solubilising bonemeal was effected. Solubilized bonemeal gave very satisfactory results as a manure for wheat and gram, as the following tables show.

WHEAT.

Plots four times repeated.

Manure applied	Percentage increase over control (no phosphate)	
	Grain	Straw
Bonemeal	3.1	3.2
Solubilised bonemeal	19.0	7.8
Superphosphate	15.1	11.0

GRAM.

Plots seven times repeated.

Manure applied	Percentage increase over control (no phosphate)	
	Grain	Straw
Bonemeal	7.7	7.9
Solubilised bonemeal	14.4	17.8
Superphosphate	15.3	6.2

Mahua cake. A further series of manurial trials with *mahua* (*Bassia latifolia*) cake that had undergone various treatments confirmed former results that the cake fermented with charcoal gave the best crop yield.

IV. DAIRY BACTERIOLOGY.

The average plate counts of the milk are given in tabular form and compared with the corresponding counts of the previous year.

Month	Average count per c.c. milk		<i>B. Coli</i> in 1-100 c.c.	
	1927-28	1928-29	No. of days present	No. of days absent
July . . .	19,300	17,300	5	9
August . . .	27,800	22,250	7	4
September . . .	33,300	22,150	2	10
October	13,700	17,000	6	4
November . . .	12,000	12,600	5	8
December . . .	9,300	12,000	0	9
January	6,100	9,400	0	12
February . . .	3,800	9,900	0	12
March	4,400	8,800	3	9
April	12,700	15,450	4	10
May	14,900	19,800	1	12
June	15,400	12,600	6	6

On thirty-three days *B. Coli* was absent in 1-10 c.c. The influence of the season of the year on the counts, both plate and *Coli*, is again well illustrated.

Plate counts of the morning milk, taken twice a week from July 1928 to March 1929, gave very much higher figures. From July to October the counts were from two to three millions per c.c., and in the following months were : November 358,000 ; December 73,000 ; January 49,000 ; February 166,000 ; March 377,000. *B. Coli* was almost always found in 1-100 c.c.

Counts of the samples of milk, carefully drawn into sterile flasks at the milking time, showed great variations from day to day and a few cows all gave high counts. These last were old cows with leaky teats. Comparison of such samples with samples drawn from the total yield of a certain cow at milking and with the counts of the mixed milk of the herd on the same day were made on twenty-two days spread over

two months. The average counts obtained were for the middle milk 3,400, for the total yield of the cow 11,100, and for the mixed milk of the herd as delivered to the customer 14,800.

The heaviest contamination occurred during the milking of the cow, and it is then that organisms of the *B. Coli* type appear to find their way into the milk, and consequently cannot be kept out by the most scrupulous washing and sterilizing of utensils.

As the type of colon bacillus occurring in milk is of importance from the sanitary aspect, the various types were isolated by plating on Endo's agar and Levine's classification applied. In seventy days, from January to June, *B. Coli communis* was found on seven days only, always associated with other forms. *B. acidi lactici* was found on 55 days and usually predominated, except in the month of June when *B. lactis aerogenes* was the chief contaminator. These investigations will be carried on for twelve months in order to see if there is any characteristic seasonal variation in the types found.

The experiments on the keeping quality of milk started last year were continued and the results in the second year confirmed those of the first, namely, that the keeping quality is about twice as high from November to March as it is from April to September.

V. EFFECT OF E. C. AND FORMALIN ON BACTERIAL SPORES.

Experiments testing the comparative efficiencies of E. C. and formalin in killing certain bacterial spores were carried on in order to find out if the substitution of E. C. for formalin for disinfecting silk nurseries would be advantageous. It was found that, in general, a concentration of 1 in 10 of formalin was needed to kill the spores of many of the bacteria tested. Greater dilutions proved ineffective even after long periods of contact. Using E. C., it was found that the time which this antiseptic was in contact with the spores was more important than its concentration. Thus a dilution of 1 in 1000 of E. C. (2 per cent. available chlorine) killed the spores of *Bacillus subtilis* in ninety minutes, while a dilution of 1 in 200 requires 60 minutes.

The resistance of spores of various soil organisms to antiseptics was found to be very variable from species to species. A dilution of 1 in 100 E. C. needed 150 minutes' contact to kill spores of *B. Mesentericus*, and this exposure to 10 per cent. formalin failed to kill them. Spores of *B. Megatherium* were killed in 30 minutes by 1 in 2000 E. C., and by 10 per cent. formalin in five minutes.

As a result of the experiments, certain modifications in the practice of spraying silk nurseries were suggested, and further experiments are in progress in connection with the use of E. C. in combating the diseases muscardine, flacherie and pebrine.

The manufacture of E. C. in the Section for use in the hospitals, dairy and wells of the estate was continued throughout the year.

VI. FERMENTATION PRODUCTS.

An attempt was made at preserving cabbage by the Sauer Kraut fermentation. There is a glut of cabbage in Bihar in March and April, followed by a scarcity of green vegetables later on, so the practicability of preserving a portion of the surplus to a later period in the year, when it would be welcome, was considered worthy of investigation.

The cabbage was finely chopped, $2\frac{1}{2}$ per cent. of common salt added, and stored anaerobically. After two weeks the extruded liquid was found to contain 1.6 per cent. acid and had a hydrogen ion concentration pH 3.2. The organism responsible for the fermentation was a *Lacto bacillus*, with characters closely resembling those of *Lacto bacillus fermentatæ* Bergey et al.

XII. STORAGE EXPERIMENTS.

Potatoes. Two lots of potatoes were stored from March to October, 1928. One lot had been grown in the experimental area; the other was purchased locally. Each lot was divided into two portions and stored in boxes, one with cinders and lime and the other with no treatment. The potatoes were not examined till the end of the experiment. The percentages of the original weight of sound potatoes recovered were as follows:—

Experimental area	.	.	No treatment	.	.	75 per cent.
Ditto.	.	.	Stored in cinders and lime	.	.	80 per cent.
Purchased	.	.	No treatment	.	.	<i>Nil.</i>
Ditto	.	.	Stored in cinders and lime	.	.	34.4 per cent.

The rotting had just started in the potatoes grown in the experimental area.

Other lots of purchased tubers were examined periodically, and the rotting tubers removed. The percentages recovered sound were stored in cinders and lime: 57.5; No treatment: 45.5. These results show the importance of picking out rotten tubers, and the advantage of storing the tubers in lime and cinders. Potatoes stored in charcoal were recovered in a sound condition.

Cold storage of mangoes. These experiments were concluded, and the results submitted for publication in "The Agricultural Journal of India."

VIII. PLANT DISEASES.

Sugarcane mosaic. Further cytological investigations of diseased and healthy leaves were carried out in collaboration with the Imperial

Mycologist. The differences observed between healthy and affected plants appeared to be quite distinctive.

Citrus canker. Citrus leaves affected by this disease were received from the Economic Botanist, Assam.

IX. PROGRAMME OF WORK FOR 1929-30.

1. Soil nitrogen and nitrogen fixation.
2. Nitrification in acid soils.
3. Silage bacteriology.
4. Dairy bacteriology.
5. Disinfection with E. C.
6. Plant diseases.

X. PUBLICATIONS.

- | | | |
|---------------------------------------|----------|---|
| WALTON, J. H. | . . . | Nitrification of Calcium Cyanamide in some Indian Soils. (<i>Mem. Dept. Agri. India, Bact. Ser.</i> , Vol. II, No. 2.) |
| ,, | ,, . . . | Investigations in the Bacteriology of Silage, 1926-27. (<i>Agri. Res. Inst., Pusa Bull.</i> No. 182.) |
| RAM AYYAR, C. S., and
JOSHI, N. V. | . . . | Preservation of Mangoes by Cold Storage. (<i>Agri. Jour. of India</i> , Vol. XXIV, Part II, March, 1929.) |

REPORT OF THE IMPERIAL MYCOLOGIST.

(W. McRAE, M.A., D.Sc., F.L.S.)

I. CHARGE AND ESTABLISHMENT.

Dr. McRae held charge of the Section till 23rd June, 1929. He was appointed to officiate as Joint Director from 9th March and as Agricultural Adviser to the Government of India and Director, Agricultural Research Institute, Pusa, from 12th April, 1929. Mr. Dastur, Mycologist to the Government of the Central Provinces, took charge of the Section from 24th June, 1929. Mr. M. Mitra, First Assistant, was absent on leave in England throughout the year, and Mr. L. S. Subramaniam acted in the post. On the completion of Mr. Mitra's period of study in the Imperial College of Science and Technology, he was awarded the degree of Doctor of Philosophy by the London University. The post of Second Imperial Mycologist was still held in abeyance.

II. TRAINING.

Messrs. Pasupati Ram Mehta, B.Sc., and Tribhuwan Ram Mehta, B.Sc., were admitted for post-graduate study in November, 1928. Mr. R. N. Tandon, Demonstrator in Botany, Allahabad University, worked in the herbarium in December on a collection of fungi made by him around Allahabad and Naini Tal. Sixty-three specimens were fully named and thirteen were identified to the genera. These will be studied further when more material becomes available.

III. DISEASES OF PLANTS.

1. *Wilt of rahar* (*Fusarium vasinfectum* Atkinson on *Cajanus indicus*). At one end of each of the plots in the three pairs laid down two years before to test the velocity of spread of wilt in land manured with superphosphate and land given no superphosphate, infective material was placed. It consisted of pieces about three inches long of the lower parts of stems that had wilted in the previous season. One piece was buried in the furrow between a group of four plants in the two adjacent ridges and three such rows of infective material were laid out. The plants were spaced three feet by three.

Number of wilts in the four artificially infected rows in each plot.

—	Super	No Super	Super	No Super	Super	No Super
Plot	10 D	11 D	25 D	26 D	27	28 D
No. of wilts . .	118	115	119	116	120	111

Number of wilts in the rest of the plot excluding those due to fugitive infection.

—	Super	No Super	Super	No Super	Super	No Super
Plot . . .	10 D	11 D	25 D	26 D	27 D	28 D
No. of wilts .	448	142	104	92	274	59

In each plot almost all plants in the four rows containing 120 plants became infected. In two pairs the number of wilts in the superphosphate plots is greater than the number in the no superphosphate plots by 3 and 4·5 times, while in the third pair the numbers are almost equal. The previous year's figures showed that the wilt was better established in the superphosphate plots and this year's figures show that the wilt has spread more in the superphosphate plots. There was a considerable number of wilts whose position was too far from the four infected rows at the end of the plots to be really due to spread from these rows. These cases of fugitive infection have been omitted. Care was taken during the cultivation to minimise the spread of infected soil from the infected portions of each plot to the uninfected portion, but this year's experience has shown that it is almost impossible to prevent this entirely in plots of this size.

Number of wilted plants on the Permanent Manurial Plots at Pusa.

A Series.

Plot	Manures applied per acre	Average No. of wilted plants in the previous five seasons	No. of wilted plants in 1928-29	Percentage of wilted plants in 1928-29
I	No manure	365	467	11·4
II	Farmyard manure to supply 10 lb. nitrogen per acre.	406	350	10·0
III	Farmyard manure to supply 20 lb. nitrogen.	328	213	6·8
IV	Farmyard manure to supply 30 lb. nitrogen.	603	382	12·4
V	Rape cake to supply 20 lb. nitrogen .	257	160	5·2
VI	Sulphate of ammonia to supply 20 lb. nitrogen.	177	167	5·3
VII	Sulphate of potash to supply K ₂ O as in No. III.	208	96	2·9

*Number of wilted plants on the Permanent Manurial Plots at Pusa.**A Series—contd.*

No.	Manures applied per acre	Average No. of wilted plants in the previous five seasons	No. of wilted plants in 1928-29	Percentage of wilted plants in 1928-29
VIII	Superphosphate to supply P_2O_5 as in No. III.	1,025	912	28.6
IX	Sulphate of potash to supply K_2O as in No. III.	1,225	987	24.8
	Superphosphate to supply P_2O_5 as in No. III.			
X	Sulphate of ammonia to supply nitrogen.	1,371	1,094	27.1
XI	Sulphate of potash to supply K_2O as in No. III.			
XII	Superphosphate to supply P_2O_5 as in No. III.			
XIII	Deep-rooted leguminous crop (<i>rahar</i>) in a cereal rotation.	295	127	2.9
XIV	One-deep-rooted (<i>rahar</i>) and one shallow-rooted (peas) leguminous crop in the rotation.	203	151	3.5
XV	A leguminous crop and green-manure in the rotation.	50	58	1.6
XVI	Green-manure and superphosphate to supply P_2O_5 as in No. III.	314	555	12.7

The incidence of the disease, though slightly less this season, is in general conformity with that of previous years.

If the plots are considered with regard to the presence or absence of superphosphate, it again appears that superphosphate encourages the disease, and that green manure discourages it. When both green manure and superphosphate are applied, the number of wilted plants is intermediate between what it is when the two manures are applied separately.

	Average no. of wilted plants	Average percentage
Plots with no superphosphate and no organic manure—I, XIII, XIV, VI, VII.	201	5
Plots with superphosphate—VIII, IX, V . . .	997	25
Plot XV with green manure	58	1.6
Plot XVI with green manure and superphosphate	555	12.3

A sufficient number of observations have now been made on this point in these plots and next year a modification will be made in that a resistant variety of *rahar* will be sown.

The investigation, which has for its object the isolation of a type of *rahar* which will be resistant to wilt disease, was continued in collaboration with the Imperial Economic Botanist. Considerable success has been achieved and the record of the work will be published.

In an artificially infected plot, which has retained its high degree of infection for several years, two of the types, T₁ and T 204, isolated in the Botanical Area by the Imperial Economic Botanist and his First Assistant, Khan Sahib Abdur Rahaman Khan, were sown. T₁ was known to be highly susceptible and T 204 was like one of our resistant varieties in morphological characters, though later observations have shown that there is a difference in the characters of the pods and seeds. All the one hundred and twenty-six plants of T₁ died of wilt, and 370 out of 525 plants of T 204 died of wilt. This experiment was intended to show whether T 204 was wilt-resistant, as a good deal of seed of T 204 was available, but the result shows that it is not.

To see the effect of superphosphate on the root development of *rahar* plants, ten pits 2.5 by 2.5 feet and 3 feet deep were dug. Each foot of soil was kept separate. Sufficient water was added to bring the moisture content of each layer to the optimum for Pusa soil, and also superphosphate to make the soil contain 0.002 per cent. of soluble P₂O₅. Each layer was replaced and carefully packed in the process. Seed was sown after the rains in September and no water was given during the five months the plants were growing. In the first two layers containing superphosphate the larger roots were more numerous and the branching rootlets were very much more numerous. In the lowest layer the difference was not particularly marked.

2. *Mosaic disease of sugarcane.* (i) *Distribution* : In addition to the varieties mentioned in the last three reports, the following canes have been observed to have mosaic disease :—

Bihar, Pusa. Four varieties in small plots in the nursery viz., P. O. J. 2696, B. S. 15, Co. 307 and B. S. 14 had 1.7, 9, 14 and 31 per cent. of clumps infected respectively.

Punjab, Lyallpur. Co. 287 had 12 per cent. infected.

Gurdaspur. In one-sixteenth acre plots, Co. 255, Co. 285, Co. 289, Co. 290, Co. 294 had a few cases amounting to less than one per cent., while Co. 250 had 11 per cent. In small nursery plots Dhaula and Pounda had a few cases, while Tereru and Kahu (Uba, Bihar) had every clump infected.

Madras, Coimbatore, Thin Cane Breeding Station. Two crosses with only station numbers at present had one infected clump each.

Coimbatore, Thick Cane Breeding Station. B. 254, M. 90, S. W. 111

H. M. Black and two crosses had one infected clump each.

Coimbatore, Central Agricultural Station. *Pennisetum purpureum*
near the cane area on the wet lands was found to be infected.

(ii) (a) The amount of mosaic disease this year on the farm fields was somewhat less than it was last year except that Co. 205 again became badly infected. This cane is so susceptible that for this and other reasons it will cease to be grown around Pusa. Rogueing, carried out as it can be done on a field scale by growers, has now been tried for three seasons at Pusa, but the disease, though reduced to such a small amount as to be eliminated as a possible controlling factor of tonnage, has not been completely eradicated. This shows the limitation of the present method which is due to the fact that a few canes show mosaic symptoms late and in a few more the symptoms disappear early.

Mosaic disease on sugarcane at Pusa.

	PERCENTAGE OF MOSAIC STOOLS				AREA
	1925-26	1926-27	1927-28	1928-29	1928-29
Co. 205 . .	+	60	5.4	14.6	2.65
Co. 210 . .	2.5	0.01	0.01	0.02	5.83
Co. 213 . .	5.10	1.2	0.5	0.3	17.27
Co. 214 . .	0	0	0	0	2.57
Co. 248 . .	0	0	0	0	0.08
Co. 270 . .	0	0	0	0	1.05
Co. 273 . .	0	0.01	0.02	..	0
Co. 275 . .	1	0	0.03	..	0 ¹
Co. 280 . .	0	0	0	0	0.15
Co. 281 . .	3	+	0.36	0.4	0.24
Co. 282 . .	3.6	+	3.05	0.5	0.16
Co. 287 . .	1.5	+	1.27	0.8	2.44
Co. 290 . .	0	0	0.008	0.03	2.44

The sign .. indicates that the variety is no longer grown at Pusa.

The sign + indicates the presence of mosaic though the percentage was not determined.

(b) Of the eight varieties that had mosaic disease in the nursery in 1927-28, four are free and four still have a few cases of the disease. Fortunately these were grown in the field. In 1928-29, of the 30 varieties in the nursery, only one clump of B. S. 14 showed the symptoms and one doubtful case was destroyed. However, during the monsoon of 1929, two clumps were found in P. O. J. 2696 or 2 per cent. of the plants, 11 in Co. 307 or 12 per cent., 20 in B. S. 15 or 8 per cent., and 45 in B. S. 14 or 23 per cent.

This sudden variation in the amount of disease in a nursery that is under careful observation is perplexing and calls for continued study. No colonies of *Aphis maidis* have been found on this cane in 1929 and it may be that an unsuspected vector is carrying the disease.

(c) With a view to estimate the amount of mosaic disease in the western part of North Bihar, cane-fields in 22 localities were examined. A sample-count was made in each field and the result is summarised as follows :—

	Hemja	Co. 213	Co. 205
Acres	7	16	30
Clumps examined	16,669	16,974	42,463
Percentage with mosaic . . .	21	1	7
Variation in percentage of mosaic .	15.5 to 25.7	0.3 to 3	4.5 to 13

(d) The disease in the Gurdaspur Agricultural Station in the Punjab has been reduced by the effort of the Deputy Director in charge. An examination of the canes showed that eight varieties had less than one per cent., Co. 251 had 5 per cent., Co. 223 had 9 per cent., Co. 205, Co. 210, Co. 250 and Co. 287 had 11 per cent., Co. 270 had 17 per cent. and S. 48 had 55 per cent. All other varieties showed no symptoms.

In the nursery two varieties had very slight infection and two Tereru and Kahu (Uba, Bihar) were fully infected.

At the Lyallpur Agricultural Station, four varieties on 1-2 th acre plots have the disease, viz., Co. 205 with 0.5 per cent., Co. 213 with 2, Co. 287 with 12 and Co. 223 with 18 per cent., while Co. 210 and Co. 285 were free.

(e) In the Manjri Agricultural Station, after drastic elimination and careful selection by the Deputy Director in charge, the disease has been reduced to a very small quantity. Pounda, the common variety in the surrounding district, seems to be free.

(f) The Dairy Farm at Karnal is still free from the disease.

(g) *Infection experiments.* Similar infection experiments to those of last year were repeated with confirmatory results. In addition, the disease has been transmitted from P. O. J. 2696 and B. S. 14 to Co. 213.

Mosaic infections.

	No. of shoots in- oculated	No. of shoots showing mosaic	Date	Incubation periods in day
Co. 205 to Maize, White big, Pusa Farm selection.	71	20	5-7-28	9 to 22
Co. 213 to Maize, White big, Pusa Farm selection.	75	48	5-7-28	7 to 12
Co. 287 to Maize, White big, Pusa Farm selection.	65	45	5-7-28	7 to 12
Co. 205 to Maize, White medium, Pusa Farm selection.	43	11	16-7-28	13 to 17
Co. 213 to Maize, White medium, Pusa Farm selection.	54	33	16-7-28	7 to 12
Co. 287 to Maize, White medium, Pusa Farm selection.	49	42	16-7-28	7 to 12
Co. 205 to Yellow maize, Pusa Farm selection.	69	8	11-7-28	15 to 24
Co. 213 to Yellow maize, Pusa Farm selection.	71	35	11-7-28	9 to 14
Co. 287 to Yellow maize, Pusa Farm selection.	69	29	11-7-28	9 to 14
Co. 205 to Maize, Pusa Farm crop .	66	2	11-7-28	10
Co. 213 to Maize, Pusa Farm crop .	63	34	14-7-28	9 to 14
Co. 287 to Maize, Pusa Farm crop .	72	36	14-7-28	9 to 14
Co. 205 to Uba	8	2	14-7-28	35
Co. 205 to Jowar	78	5	20-7-28	13
Co. 213 to Jowar	75	34	21-7-28	7 to 10
Co. 287 to Jowar	65	3	23-7-28	12
Co. 213 × Maize to Maize . .	57	32	26-7-28	9 to 13
Co. 213 × Maize to Maize . .	59	35	26-7-28	9 to 13
B. S. 14 to Co. 213	5	4	25-4-29	18
P. O. J. 2696 to Co. 213 . . .	6	2	8-7-29	28

(h) *Tonnage experiment.* An acre of Co. 213 from setts taken from cane whose leaves had mosaic symptoms was grown alongside an acre of Co. 213 from setts selected from cane with no mosaic symptoms. The former produced 387 maunds of stripped cane and the latter 407 maunds. In the same conditions a quarter acre of mosaic Co. 205 produced 143 maunds, while the same area of non-mosaic Co. 205 produced 137 maunds (1 maund = 82.4 lb.). The differences are small and are within the error of experiment, so again no loss in tonnage was demonstrable.

Top rot of Sugarcane. During the last four years a disease of sugarcane which appears to be identical with the Pokkah-bong disease of Java has appeared in stray clumps in a grower's field in Bihar. The disease so far has not caused any damage, but it is becoming slightly more common. It was noticed for the first time in 1925 during July in North Bihar when a survey was being made to determine the presence of mosaic disease in various parts of the white sugar belt. Scattered cases of this disease were observed on Co. 210 and Co. 213. The first visible symptoms of the disease are the appearance of pale red patches on the lower portions of the young and unfolded leaves where they are attached to the leaf sheath. These patches become darker in colour later on and begin to split. Sometimes chlorotic patches appear first and then reddening appears. Holes are found on the leaves and sometimes splitting of the leaves at the point of attack is very prominent. Occasionally, when the new leaves expand, they are caught in the old split leaves. Then the whole crown becomes twisted and curled. In light attacks the leaves open normally but are short in length and the stalk continues to grow. Such stalks are very thin at the top and the internodes are shortened and do not attain full growth like the healthy ones. In severe cases the reddening extends to the spindle, the leaves do not open but remain attached to the stalk and the tip of the stalk becomes pointed. The growth of the plant is arrested, the tips of the unopened leaves become deep brown and curled, the growing point rots within and a wet rot is set up. Generally all the stalks in a stool are not affected. The disease begins to appear at the break of the monsoon and continues throughout the rainy season.

A species of *Fusarium* was found in the reddened patches but pure cultures did not induce this condition direct. The presence of punctures in the diseased shoot led us to think at that time that the diseased condition was due to insect attack. This was investigated at Daultapur by the Imperial Entomologist in 1925, and reported that it was due to the attack of top shoot borer (*Scirpophaga xanthogastrella*).

3. *Piper betel.* In contradistinction to its entire absence in the previous year, the wilt appeared in all the plots under experiment this season. There was little disease during the monsoon, but it became severe in

November and continued lightly during the rest of the season with a slight rise in March. Of 403 wilted plants from Chinsurah, 7 had *Sclerotium*, 36 had *Phytophthora*, 265 had *Rhizoctonia*, and 95 had both *Phytophthora* and *Rhizoctonia*. Instead of being a disease of the monsoon it has, this year, been a disease of the post-monsoon period, and *Rhizoctonia solani* has been the chief cause. At Banhoogli and Santragachi the sprayed plots remained almost free from disease, while in the unsprayed plots 18 to 30 per cent. of the plants became wilted. When vines reach the roof of the shed in which they are grown, they are usually brought down and the stems laid along the ridge so that new buds may sprout to make new shoots. Instead of doing this, the stems were looped or trained along trellis-work in order to keep them off the ground and so away from contamination. This practice, however, materially reduces the number of leaves produced and as the plucked leaves form the crop, this practice alone does not seem to be of much promise, although in a year when the disease is very severe it might be of use in order to get a reduced crop rather than none at all. So effective was the spraying in Banhoogli that surrounding growers made up their minds about its efficacy, purchased spraying outfits and sprayed their own plots. Cultures of the *Phytophthora* from Bengal, Madras and Malay were placed each on six vigorously growing plants of the Daldhoga variety of betel vine from Bengal under the moist conditions in the month of July. All of the plants became infected by the cultures from Bengal and Madras, but only one became infected by that from Malay.

4. *Cinchona*. Four diseases of *Cinchona ledgeriana* were under investigation at Mungpoo and Munsong cinchona plantations, viz., Pink-disease, Bleeding disease and "Stem rust", Seedling disease in Munsong and Seedling disease in Mungpoo. (a) Pink-disease caused by *Corticium salmonicolor* B. et Br. was found chiefly on the branches but sometimes also on the main stem. The leaves on one or more branches become brown and withered and may remain attached to the branches. On the branch some distance below, linear rose-pink pustules appear sometimes filling the lenticels or extending beyond them. Crusts of this dense rose-pink mycelium cover considerable areas of the branch. Later on the rose-pink tint gradually disappears and the crusts and pustules become dirty white and covered with minute irregular cracks. Sometimes the bark is covered with long silky hyphæ of a silvery white appearance. The diseased area of bark may be on one side only or extend right round the branch or stem. Below the diseased part numerous buds develop into shoots. This disease is fairly common in the plantations.

(b) *Bleeding disease*. Near the base of a dying tree nine years old were red areas on the surface of the bark and narrow streaks downwards as if a liquid had oozed out, run down, and dried up. Under these

patches the bark was brown and dead to a varying depth, sometimes only just below the normal outer covering of dead bark, at others as far as the cambium. Small areas of disintegrated cells were found from which bleeding probably occurred. The bleeding fluid was soluble in acetic acid and in alcohol, leaving a small residue of collapsed and broken cells. No hyphæ were seen in sections of this dead bark. Bleeding takes place on the stem and occasionally on the branches and occurs chiefly in the hot weather about April.

The manager of Mungpoo thinks that a branch or a tree dies within nine months of the appearance of bleeding. It is a general impression, however, and not a deduction from observation of marked trees. Considerable areas of the bark especially towards the base of the stem are sometimes covered with a rust-brown stain. The tint reminds one of the colouration on stones, etc., in a stream that has iron in solution. Below this stain the bark is brown and dead usually to the cambium and sometimes the wood too is tinted brown. When the stains are small and numerous, the bark below each is brown and dead in little patches and when cut with a knife has a mottled appearance. This stem-rust is sometimes associated with this bleeding disease and sometimes not. In the plantation they are looked on as one disease, but it is possible that they have different origins, though the Imperial Mycologist's observations did not elucidate the point. The cell-walls of the brown bark are stained deeply, the cell contents are collapsed and stained. Compound starch grains are often present in abundance, also amorphous precipitates that are cleared with dilute potash and alcohol and are probably alkaloids. Usually no hyphæ are found in the tissue. This disease is bad both at Mungpoo and Munsong on the blocks planted in 1919 and is worst at an elevation of from 2,500 to 3,500 feet. In Mungpoo the 1919 block is 120 acres in extent and held 59,000 trees in 1928. During this year's harvesting operations, 11,221 trees were cut out for bark and the manager thinks that a large proportion looked unhealthy and probably had bleeding disease. A severe hail-storm in the hot weather damaged the trees in this block extensively. On every one are numerous places where the hail-storm had removed the bark in patches of about $\frac{1}{2}$ to 1 inch in diameter, but no bleeding was visible at the torn edges.

A few trees that were dying had the rusted appearance on the bark near ground-level but few obvious marks of bleeding. In some the bark had cracked in longitudinal fissures several inches in length exposing the wood. Between the dead bark and the wood of one tree a layer of white to pale-yellow septate hyphæ 3.5 to 5.5 μ in diameter were seen with numerous clamp connections. These were also found in the cells of the wood but not in the bark. This puts the fungus among the basidiomycetes several of which are known on cinchona, but the

aterial was too scanty for diagnosis. In the cens of the wood and sparingly in those of the bark of another tree, another fungus was found 4.7 to 7 μ in diameter, hyaline to brown in colour. It was sparingly septate, lengths up to 140 μ being without septæ. This fungus is being brought into culture. From each block of cinchona in bearing, a certain number of trees are taken for bark each year. The areas are gone over two or three times each season and dead or diseased branches and dead, diseased or unhealthy looking trees are taken out as well as the requisite quota to produce the predetermined amount of bark required. Thus in the nature of the harvesting operations, plant sanitation is attended to very carefully. Though the total number of trees removed from each block is known, yet no record is kept of the number of diseased trees. It is thought that now-a-days the proportion is high though perhaps not much higher than it has been hitherto.

(c) *Seedling disease at Munsong*. On plants 15 months old the upper leaves assume a dingy yellow hue, all the leaves become red and droop and the plant dies. Slight longitudinal depressions appear in the lower part of the stem. The largest is about $\frac{1}{4}$ inch broad and several inches long. Below the depressions the bark looks dry and is brown and the browning sometimes extends into the wood. The cell walls of the bark are brown, and have collapsed. The cell walls of the cumbium are brown and also the outer layer of cells of the wood. The inner layers and the pith are uncoloured. Much starch is in the cells of the cortex, wood and pith. Very few hyphæ were found in the cells and, as a rule, they were near the periphery. These hyphæ were so few as to suggest that they are unlikely to cause the death of the bark. The seedling disease occurred in 1927 and in 1928 in three-year old nurseries. In October a few plants became diseased and the number gradually increased till in April and May the disease was epidemic and thousands of plants died. Plants from the infected nurseries that appeared not to be infected when planted out in 1927 showed the symptoms and died during the year and this is happening again in 1928. The infected nurseries were at both high and low elevation. In one-year old nurseries there was hardly any loss and in two-year old some loss. In past years nurseries are said to have been used for longer than three years without untoward results. The fact that cinchona does not grow well on the site of old nurseries is perhaps germane to the enquiry. In both years the monsoon came early and was not excessive. In the former year there was an early break and in the latter it was continuous, so it is unlikely that the weather conditions are responsible for the disease. Drought and excess of water are said to induce the same appearance as these diseased plants have, though the longitudinal stripes of dead bark have not been looked for in such conditions. It has been observed that plants whose leaves are attacked by mosquito blight (*Helopeltis*,

do not take the disease. *Helopeltis* partially defoliates the plant and the tips of branches die-back. Planting was later than usual in both years and there has been a tendency to plant later year by year because experience has shown that more plants survive after being planted out. It is perhaps possible that seeing the plants are longer in the nursery they are too close for their size. The effect of mosquito blight in destroying the upper leaves is to let more light and air into the region round the stems of the young plants, so wider planting than 4 inches by 4 inches in the nursery is to be tried.

(d) *Seedling disease at Mungpoo*. In very wet weather or when a nursery is over watered, small patches of seedlings die. From seedlings got from Mungpoo last year, a *Phytophthora* was cultivated. On three occasions in Pusa, fifteen young seedlings were inoculated and 9, 15 and 10 seedlings died. Again in July seedlings were brought from Mungpoo. Seven of them were inoculated on the stem and all became infected and died. The eight plants not inoculated are still healthy. The average temperature was about 27°C. While in Sureil some seedling plants were inoculated, but they did not become infected. The temperature at Sureil was about 20°C. and was probably too low, as Sureil is well above the elevation where cinchona is grown. At Munsong, however, many seedlings that were inoculated died and that the temperature was about 22°C.

The temperature relationship of cinchona are given by A. T. Gage, in his Report on the Extension of Cinchona Cultivation in India, Calcutta, 1918. The *Phytophthora* was placed in the middle of petri dishes kept at such temperatures and on the eighth day the mycelium had extended to the following distance.

Cinchona	Phytophthora
30°C. mean maximum	7.8 c.m.
24°C. optimum	8.4
16°C. mean minimum	3
0°C. Fatal . . . . .	.5

There is no doubt about the fungus being parasitic under moist conditions in seedling plants. Great care is exercised during the whole course of their year in the nurseries to keep the seedlings in the correct conditions of moisture in order to prevent their dying and nothing better than standard practice can be suggested against this fungus.

5. *Gram diseases*. (a) *Mystrosporium* blight appeared again on the following cultures grown in the Botanical Area :—P. 7, 8, 9, 10, 11, 12,

15, 19, 20, 33, 35, 39, 40, 41, 42, 43, 44, 52, 53, 54, 55, 56, 56, 57; YG. 2, 4, 6, 10, 13, 16, 17, 21, 27, 28, 29; BG. 1, 7, 9, 11; KS. 1, 3, 6, 11, 16; and KL. 2. The disease appeared in a greater number of varieties this year. In many varieties the seed production was affected and in P. 42 no seeds were produced. Infections with this fungus were carried out on 30 types of gram and all were found to be susceptible. The fungus grows well on all meal media, but the growth was poor on starch, glucose, dextrose and potato juice agar media. There is a stromatic formation in French bean and wheat meal agar. No spore formation has been found in the structure. The growth of the fungus is checked at 34°C. and spore production almost ceases.

(b) *Wilt*. A few cases of wilt appeared in the cultures of the following varieties grown in the Botanical Area :—P. 4, 5, 8, 11, 12, 35, 42, 43, 45, 54, 55, 56, 57, 58; YG. 4, 5; BG. 11, KS. 11; KM. 2, 3 and KL. 2. Strains of *Fusarium* were isolated from 4 types, viz., P. 2, P. 5, P. 42 and KS. 11. Further studies with these strains will be taken up this cold season.

6. *Sesamum indicum*. The malformation and the proliferation of the young shoots mentioned in the last report is not due to *Sclerotium bataticolum*. However, this fungus attacks wounded plants very readily and the plants collapse soon. The infected plants are blackened and numerous pycnidia of *Macrophomina phaseoli* (Maucl.) Ashby are produced.

7. *Smut on Kodra (Sorosporium Paspali* McAlp.) The life-history of the fungus and the treatment have been worked out by Mr. Abdus Sattar, a post-graduate student. It has been found that this fungus has a resting stage of about four months. The maximum temperature for the germination of spores is between 34.5°C. and 37.5°C. and the minimum below 19°C. and the optimum about 30°C. It is mainly propagated by seed-borne spores. It can be controlled by steeping the seed grains in 1.5 per cent. copper sulphate solution for 30 minutes, then drying before sowing or by dusting the seed grains before sowing with 1 oz. of powdered copper carbonate per 10 lb. of grain. The seed grains treated with either of the above fungicides can be kept for at least two months without the germination of the seed grains being impaired.

8. *Wheat*. (a) *Helminthosporium on wheat*. *Helminthosporium sativum* was epidemic on wheat in Pusa and its near vicinity. Measurements were made of the leaf area covered by the spots caused by this fungus by comparing large numbers of leaves picked at random with type leaves whose infected area had been found by measurements. This is the method described by L. R. Tehon in *Bulletin, Natural History Survey*, Vol. XVI, 1, "Epidemic Diseases of grain crops in Illinois 1922-

26". The following table gives the percentage of leaf surface discoloured :—

Helminthosporium sativum on wheat.

	Pusa	Locality A.	Locality B.	Locality C.
Pusa 4—Smooth glumed	33	..	..	..
Pusa 4—Hairy glumed	40	..	..	..
Pusa 12	16	..	..	..
Pusa 52	18	..	0.43	1.5
Federation—bearded	31	..	..	..
<i>Deshi</i> . . . . .	..	0.9	0.23	0.1

At Karnal, 20 cultures of cross between Pusa 4 and Federation were examined and the percentage of leaf surface affected by the spots varied from 0.3 to 10.6. While in 19 cultures of crosses between P. 52 and Federation, two cultures had no disease and the others varied between 0.8 and 11 per cent.

(b) *Rust of wheat.* This year there was extremely little rust on wheat in Pusa and its vicinity. Orange rust which is always first to appear was not seen till the 30th of January, whereas it is usually present towards the middle or end of December. Black rust did not appear till the beginning of March and there was extremely little of it. By the same method as has just been mentioned, the percentage of leaf surface covered by the rust pustules was measured with the following results :—

Variety	Orange rust	Yellow rust
Pusa 4—Hairy glumed	0.6	0
Pusa 4—Smooth glumed	0.6	0
Pusa 4—10	1.7	0
Pusa 4—11	2	0
Pusa 12	15	0
Pusa 52	1.7	3
Pusa 101	3	1.6
Pusa 80—5	2.6	0
Bearded Federation	9.7	0

(c) *General.* All the wheat cultures in the Botanical Area of Pusa were examined for rusts and *Helminthosporium* and records kept. At Karnal fifteen cultures of a cross between Pusa 4 and Federation were free from rust, while 5 cultures had from 0.2 to 0.8 per cent. of leaf damaged done by orange rust and two cultures had 0.1 and 0.3 per cent. of black rust. Yellow rust was absent. Eight cultures of a cross between Pusa 52 and Federation were free from rust, while two had from 0.1 and 7.6 per cent. of leaf surface damaged by orange rust and eleven had from 0.2 to 34 per cent. damaged by yellow rust. Black rust was absent.

IV. SYSTEMATIC WORK.

During the year under report, 30 calls were received from different places to examine diseases of crops and to give advice. Besides these, 405 specimens of diseased betel vine from places in Bengal were examined. *Ustilago Zee* (Beckm.) Ung. was found on *Zea Mays* in Munson in the Darjeeling District. It occurs rarely in the Punjab and the United Provinces but is fairly common in Kashmir. The Deuteromycetes were studied and 243 specimens were sent to Professor H. Sydow, Germany, for identification. Cultures and specimens were supplied to the Mycologist Bangalore, the Assistant Plant Pathologist Bureau of Science Manila, the Government Mycologist Nagpur, the Plant Pathologist Poona, Professor of Botany St. John's College Agra, Dr. C. L. Shear Senior Plant Pathologist Bureau of Plant Industry Washington, Dr. Stewart Professor of Botany Rawalpindi, Dr. C. P. Sideris Plant Pathologist Hawaii, Dr. R. Ciferri Director Estacion Nacional Agronomica Y Colegio de Agricultura Moca Republica Dominicana, Professor of Biochemistry Indian Institute of Science Bangalore, and Director Imperial Bureau of Mycology London. Thirty-five specimens representing different groups were received from Dr. R. Ciferri. One hundred specimens of foreign and Indian Fungi were added to the herbarium.

V. PROGRAMME OF WORK FOR 1929-30.

1. *Research work.* New diseases of Indian crops that come to the notice of the Section will be investigated. The following crop diseases will receive special attention :—

- (a) Diseases of cereals.
- (b) Diseases of sugarcane.
- (c) Diseases of *rahar*.
- (d) Diseases of betel-vine.
- (e) Diseases of cinchona.
- (f) Diseases of gram.

2. *Training.* Students and assistants will receive training on the lines indicated in the prospectus.

3. *Routine work.* Advice and assistance as required will be given to other departments and the general public.

VI. PUBLICATIONS.

- | | | | | |
|-----------|---|---|---|---|
| McRae, W. | . | . | . | Report on Mycology, 1928-29, for the Committee of the Privy Council for Scientific and Industrial Research. |
| Mitra, M. | . | . | . | Some diseases of crops in the Andaman Islands. <i>Pusa Agri. Res. Inst., Bull.</i> No. 195. |

REPORT OF THE IMPERIAL ENTOMOLOGIST.

(T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.)

I. ADMINISTRATION.

Mr. P. V. Isaac held charge of the Section from 1st July to 3rd September 1928, when I returned from short leave and resumed charge.

Mr. G. R. Dutt acted as First Assistant in addition to his own duties, *vice* Rai Bahadur C. S. Misra on leave, from 1st June until the end of the year under report.

II. TRAINING.

Mr. Karam Singh Lamba, M.Sc., Post-graduate student, was under training throughout the year.

Mr. Ram Narain Singh, L.Ag., Entomological Assistant, United Provinces, completed his special two years' course in Systematic Entomology on 30th April 1929.

Mr. Pearay Mohan, M.Sc., a student deputed by the Indian Central Cotton Committee for a special short course for one year, completed his course on 31st May 1929.

Mr. K. Sontakay, Entomological Assistant, Central Provinces, was admitted from 23rd August 1928 for a special course for one year.

III. INSECT PESTS.

Sugarcane. Local canes, both cultivated and wild, were examined regularly for Borers and other insect pests, but no new Borers were found. Egg masses and larvæ of *Scirpophaga nivella* and of other Caneborers were collected regularly for the breeding of any parasites and the observation of dates of appearance of the different broods. It may be noted that the first egg-masses of *S. nivella* were laid on the newly-planted cane by the middle of April, whereas, previous to this, eggs had been laid on ratoon canes but not on the new plantings. The parasitization of egg-masses at this time of the year seems to be very small. Observation was kept on the various insects found in the mosaic and non-mosaic cane plots. Work on *Neomaskellia bergi* (Aleyrodidae) as a transmitter of mosaic in cane has hitherto given negative results. A *Pseudococcus* (Scale insect) was under study.

Specimens of *Hieroglyphus banian*, Fb., a well known grass-hopper pest of sugarcane and rice, were sent in from Azamgarh, U. P., in September 1928 as damaging sugarcane. The life-history of the sugarcane Aphid (*Aphis sacchari*) was worked out during April, when

two generations were gone through: the first took 10-11 days and the second 8 days, the weather becoming warmer.

Examination of wild grasses was continued. *Phragmataecia purpureus* (Cossidæ) was found boring in *Saccharum spontaneum* on 23 June 1928; it pupated on 29 October 1928, but the pupa died. Weevil grubs boring *Imperata arundinacea* roots were collected and are under rearing. Borers in *Cyperus rotundus* were also collected. The presence of alternative foodplants will probably be found to have an important bearing on the occurrence and control of Borers in cane.

Rice. An outbreak of Rice *Hispa* in the Sibsagar district, Assam, occurred in 1928, and Mr. Bose, Assistant, was sent on tour to give any assistance; by the time he arrived there, the outbreak was nearly over and nothing could be done. An outbreak of *Spodoptera* caterpillars occurred in September at Moulanager, Muzaffarpur District, and was dealt with. There was also a local attack of *Hispa armigera* on rice at Bhagalpur, Bihar. Caterpillars, apparently of *Nisaga simplex* (Eupterotidæ), were received from Ranchi as damaging rice but could not be reared. *Brachmia arotræa*, Mey, (Gelechiadæ) was reared from caterpillars found on rice at Pusa.

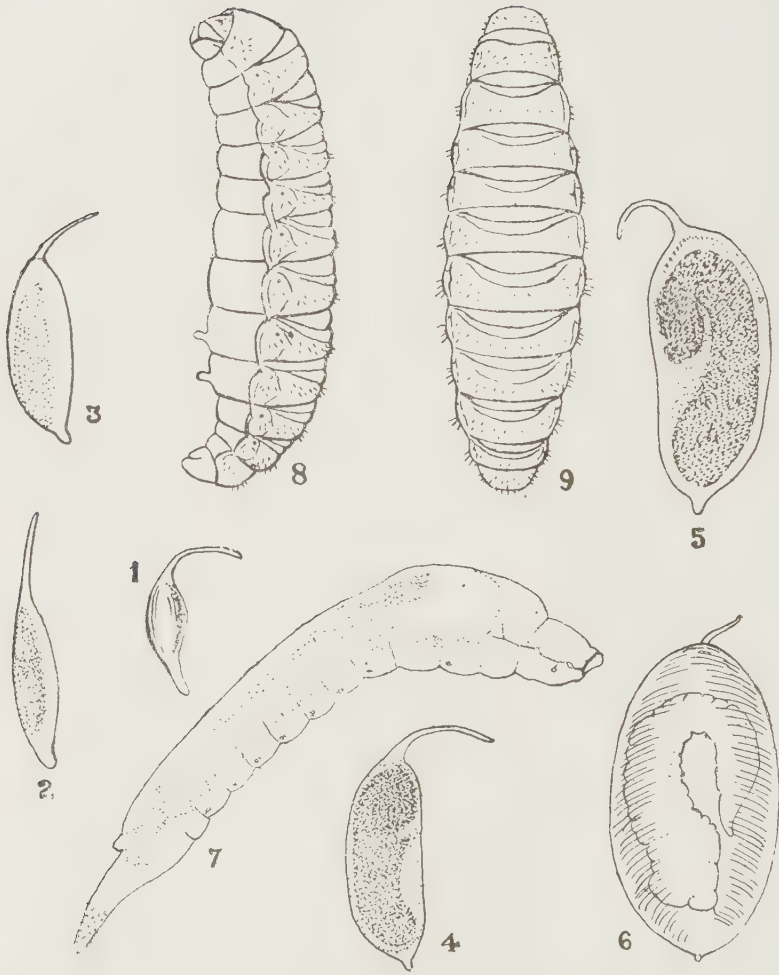
Cotton. This is not a local crop at Pusa but a small area is grown for study of Insect Pests. Considerable damage to cotton in the Punjab during the 1928 season was reported as due to an Aleyrodid, which has been under study: A Bulletin on it was written by Rai Bahadur C. S. Misra and Mr. Karam Singh Lamba and sent in for publication during the year; in this the life-history of the insect has been given and it has been described and named as *Bemisia gossypiperda*, n. sp. A few *Pempheres affinis* (Curculionidæ) were found in cotton-stems at Pusa.

Larvæ of *Platyedra gossypiella* (Pink Bollworm) were found in some numbers feeding on seeds inside pods of *Hibiscus abelmoschus* at Pusa in January.

In previous reports reference has been made to study of the life-history and habits of a Braconid parasitic on adult weevils of *Mylloceris undecimpustulatus* var. *maculosus*, Faust, and this parasite was referred to under the name of ?*Loxocephalus* sp. During the current year an interesting paper appeared in the Proceedings of the Zoological Society of London (Part II, pp. 597-630, tt. 1-4: July 1928), by Dorothy I. Jackson, on the biology of *Dinocampus rutilus*, a parasite in Europe of another weevil, *Sitona lineata*. The biology of these two parasites seemed so similar that specimens of the Indian species were sent to the Imperial Bureau of Entomology for comparison and we have received information that our parasite is a new species of *Dinocampus*, which will be described shortly.* Mr. G. R. Dutt has continued work on this

* Since described as *Dinocampus Mylloceri*, Wilkinson (Bull. Ent. Res., xx, 207-208, Aug. 1929.)

PLATE I



DINOCAMPUS (sp. nov.), PARASITIC ON ADULT *MYLLOCERUS* WEEVILS.

Figs. 1—6. Eggs of *Dinocampus* sp. showing development and increase in size ; Nos. 1—5 were secured on dissecting a single adult *Myllocerus* weevil.

Fig. 7. 1st stage, 'caudate' type larva of *Dinocampus* sp.

Fig. 8. Full grown larva of *Dinocampus* sp., lateral view showing peculiar process on the ventral side of abdominal segments.

Fig. 9. Full grown larva of *Dinocampus* sp., dorsal view.

All magnified 12 times (linear).

Braconid and evolved a technique for rearing it in captivity. A detailed account of its life-history is reserved for future publication, but a few interesting points may be mentioned here. The adult female *Dinocampus* does not seem to be aware of the presence of the weevil unless the latter is in very close proximity; but, once its host's presence is known, the parasite henceforth follows the weevil doggedly, moving as it moves and remaining still when it stops. If the weevil turns round to face its pursuer, the Braconid quickly recedes and waits until the weevil moves away again, when she follows in close pursuit. In the field such a pursuit may be watched for several minutes at a stretch, the weevil walking over leaves and branches of the *tur* plant, closely followed by the parasite. During this pursuit at times the parasite suddenly raises herself on her hind legs and bends her abdomen forwards beneath her, so that the dark valves of the ovipositor extend well in front of her head; in this position she may have to wait for some time, but as soon as a favourable opportunity occurs, she darts her ovipositor into the apex of the weevil's abdomen and deposits an egg, her ovipositor being then withdrawn and her abdomen straightened immediately. In captivity, the same parasite may oviposit several times in one weevil: five eggs were found in one weevil and eight in another, under such confined conditions. After oviposition, the egg swells considerably and, as the eggs cannot be laid all at once, there can be noticed an appreciable difference in the sizes of the eggs found inside a single weevil (Plate I, figs. 1-6). Although many eggs may be laid in one weevil, only one Braconid larva seems to attain maturity.

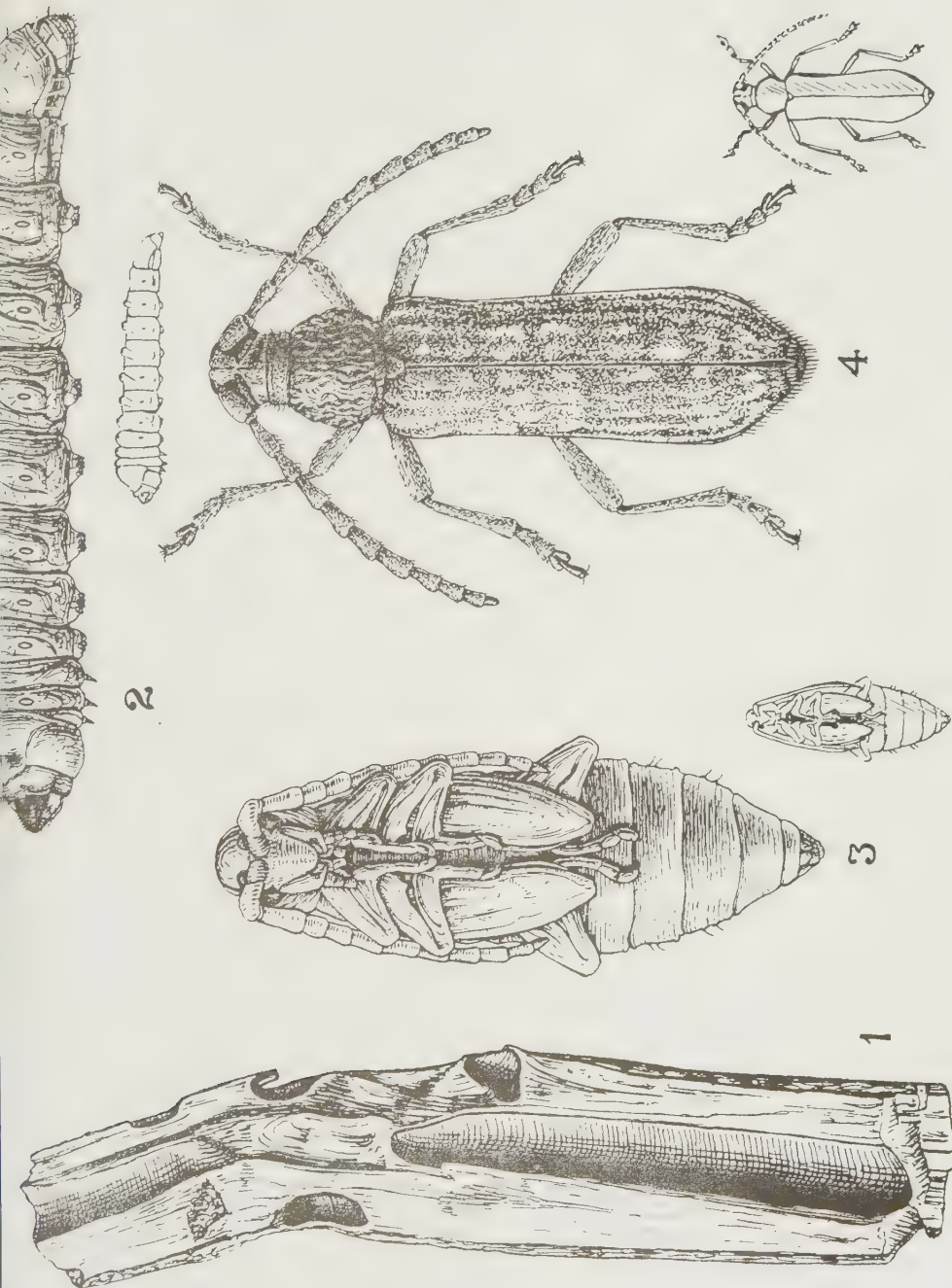
The *Dinocampus* larva moults four or five times before attaining its full growth and after each moult there is some difference in the shape of the larva, apart from the difference in size between the different instars. The first stage larva is quite a different looking grub from the penultimate-stage larva. In its first instar the larva is vermiform with a caudal outgrowth (Tab. I, fig. 7); in its penultimate instar, it is of the usual hymenopterous-grub type. The full-grown larva is again different, as it possesses two prominent ventral protuberances, one on each of the eighth and ninth body-segments (counting from the head, excluding the head) (Tab. I, figs. 8 and 9).

The fully-grown *Dinocampus* larva emerges from its weevil-host by cutting a passage for its exit through the membrane surrounding the anal aperture of the weevil, which dies soon afterwards. The larva spins a compact white silken cocoon which is sometimes attached to the ventral surface of its victim, or which may be attached to the leaf on which the weevil was resting when the parasitic grub emerged from it, or which may be found in the soil below the plant.

This parasite occurs at Pusa from the middle of November to the beginning of April.

Fruit Pests in Baluchistan received attention and Rai Bahadur C. S. Misra, First Assistant, was sent on tour to Quetta in November 1928 and May 1929 to investigate these. Both Black and Green Aphids were very bad on peach-trees, also occurring on apples and damson, the former also on apricot and the latter also on almond, plum and nectarine. An *Aspidiotus* was also present in large numbers on practically all fruit trees, the infestation being so heavy on some of the trees at Quetta that they looked white from a distance. Another Scale-insect (*Saissetia* sp.) was also present, but in less numbers, on apple, apricot, quince, damson and plum. A Cerambycid borer in peach and a Buprestid Borer in almond are also important pests.

A report was received of the damage done to mango trees by a Borer at Barsoighat, Purneah District, and Mr. Bose, Assistant, was sent there to procure material. It was found that the borers were worse on the older trees, those of 8-10 years of age beginning to be attacked. Generally the growing branches are attacked and, although many shoots on the bored branches bear green leaves and look healthy, they are bored. It is usually the thicker branches that are attacked and, when these are high up on old trees, it is not possible to detect the attack until the bored branches die back and drop off the tree. Holes in the bored branches, through which frass is extruded, and the exudation of resin and fluid from the attacked branches may indicate the seat of attack, but it is not easy to distinguish the attacked branches and shoots when these are in the upper parts of older trees, owing to the thick foliage and the continued growth of leaf from the bored branches which often throw out side-shoots. The eggs are apparently laid at the tips of the branches, the grubs on hatching boring right down in the centre of the branch, making a clear circular gallery which is kept clean. Pupation takes place in the gallery and the adult beetles, which appear during the first half of May, seem to emerge through the tip of the attacked branch. This Borer was found to be a species of *Rhytidodera* (Cerambycidae) but could not be identified more exactly at Pusa. Mr. J. C. Gardner, Systematic Entomologist at the Forest Research Institute, Dehra Dun, however, has named it as *Rhytidodera bowringi*, White, a species described from South China and not hitherto noted in the Indian Region (Plate II). The Pusa collection also contained an unnamed specimen collected many years ago at Thaton, Burma, where it was found associated with mango. It seems probable, therefore, that this Mango Borer will be found to be widely distributed in North-East India and Burma. The Burmese Mango-Borer is referred to in *Proc. Second. Entl. Meeting* (1917), p. 227, as being perhaps *Rhytidodera robusta*, but this identification now requires correction. The same, or a very similar species, was also reared at Mandalay from a larva boring *Ficus carica* (*Proc. Third Entl. Meeting*, p. 222 : 1920).



RHYTIDODERA BOWRINGI, WHITE.

1. Mango branch, showing larval tunnel (natural size).

2. Larva $\times 3$.

3. Pupa $\times 3$.

4. Beetle $\times 3$.

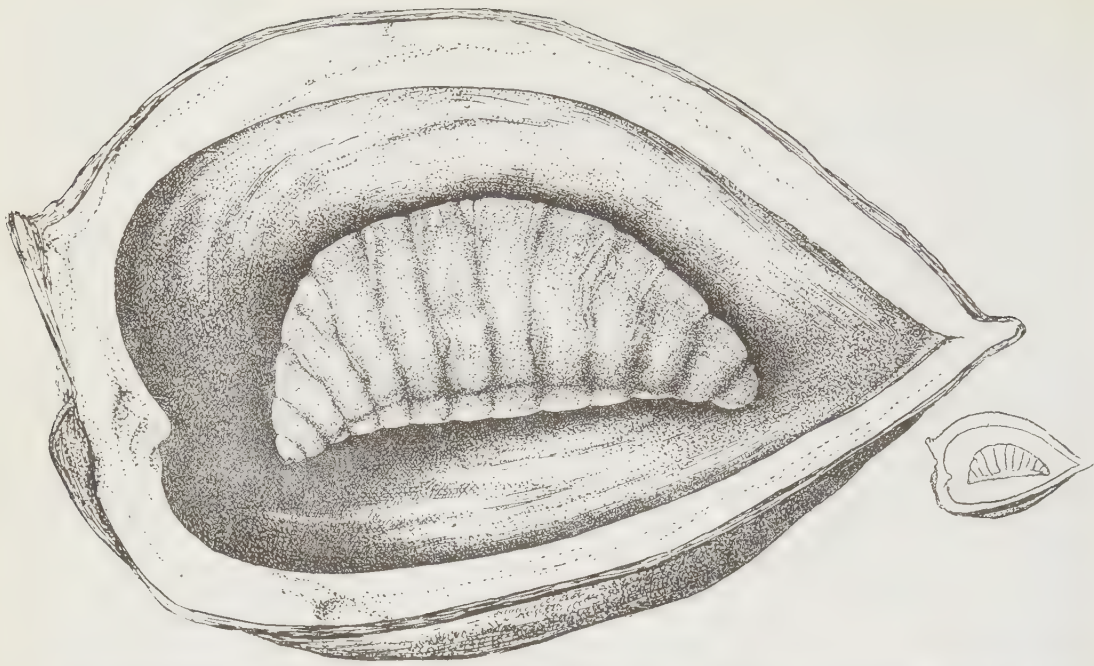


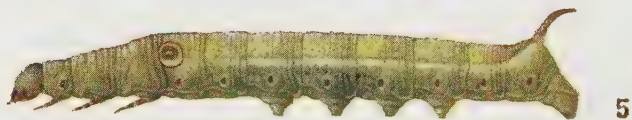
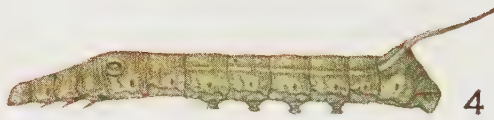
Fig. 1. An apricot stone broken open to show a full-grown Eurytomid larva inside ($\times 6$).



Fig. 2.







THERETRA ALECTO and T. CLOTHO.

EXPLANATION FOR PLATE IV.

- Fig. 1. *Theretra alecto*, full grown caterpillar.
,, 2. ,, Pupa.
,, 3. ,, Moth.
,, 4. *Theretra clotho*, caterpillar in penultimate stage.
,, 5. ,, full grown caterpillar.
,, 6. ,, Pupa.
,, 7. ,, Moth.

All the figures are life size.

All the figures are life size.

1.	"	Albino caterpillar.
2.	"	Albino pupa.
3.	"	Albino moth.
4.	"	Albino caterpillar in pupation stage.
5.	"	Albino pupa.
6.	"	Albino moth.

Fig. 1. *Herpa albata*, full grown caterpillar.

TABLE I.

A large Scale-insect (*Monophlebus* sp.) was reported as being in large numbers on *Cedrela toona* and large Sour-lime trees in the Peshawar Cantonment Area. Mr. G. R. Dutt, Offg. First Assistant, was sent to investigate but found that the gravid females had left the trees and oviposited in the soil below these. Destruction of the eggs in the soil and banding of the trees in November when the young are due to hatch out, should prove effective remedies.

Another Insect pest in the North-West Frontier Province is the Apricot Eurytomid (Plate III, fig. 1), whose larvæ live inside the kernel and cause the fruits to fall prematurely. The damage to apricot trees has been so great that the production of apricots in Haripur-Hazara has been severely affected, trees which used to yield about two maunds of fruit per tree now producing one-tenth or less of that amount. As the insect remains in the larval stage inside the kernel of the fruit for about ten months in the year, systematic collection and burning of the fallen kernels should control the pest. As some indication of the numbers in which this pest occurs, it may be stated that 1330 apricot kernels were collected from the ground below nine trees and of these 1250 were found to contain living Eurytomid larvæ.

Yet another Insect pest of the North-West Frontier Province is the Green Aphis which causes a leaf-curl of Peach leaves. It can be controlled by spraying, the usual difficulty being the non-availability of sprayers and insecticides. A spraying fluid made up of $\frac{1}{4}$ lb. weight of powdered Soap-nut (fruits of *Sapindus mukorossi*; vern. *Reetha*), in two gallons of water, in which $\frac{1}{2}$ lb. weight of country soap is dissolved, was found effective in killing this Aphid, and can be prepared from materials available locally.

A Phycitid moth (*Nephopteryx* sp.) was reared from fruits of *ber* (*Zizyphus jujuba*). *Ceroplastes floridensis* occurred during December 1928 as a bad pest on guava and the opportunity was taken to study its life-history and parasitization.

Two Hawk-moths, *Theretra alecto*, L., and *Theretra clotho*, Drury, are often minor, occasionally more serious, pests of the grapevine, the caterpillars feeding on the leaves. In their early stages these two insects are not always easy to distinguish although the moths are abundantly distinct. The caterpillars, pupæ and moths of these two species are shown on Plate IV. It may be remarked that the second to sixth ocelli along the side of the caterpillar of *T. alecto* may be more or less obsolete, when the caterpillar is not unlike that of *T. clotho*, but the ocellus on the first abdominal segment is elongated in *T. alecto*, whilst it is rounded in *T. clotho*.

Observations of leaf-curl Disease of *Hibiscus cannabinus* at Pusa showed that there are two distinct conditions associated under this name. In one condition, a hard, bunchy, curly knot is formed from the top-leaves,

somewhat similar to the effect of *Psylla* attack on Indigo or the *Tukra* disease of mulberry ; this is definitely caused by attack of a Scale-insect (*Pseudococcus* sp.). In the other condition, which was in evidence in August-September 1928, the affected plants have curly leaves and the internodes become shorter as the plant grows until they become very small and contiguous : no insect was found to be associated with this condition.

Diacrisia obliqua (Actiadæ) larvæ occurred in small numbers on Sweet-potato leaves, Velvet Bean and Cajanus. Larvæ of *Athalia proxima* (Mustard Sawfly) occurred on leaves of mustard and turnip. *Pieris brassicæ* (Cabbage White Butterfly) appeared on 12th February 1929, but seemed to be in unusually small numbers, no outbreak of caterpillars occurring on the cabbage in March as is usual. Larvæ of *Agyroploce illepidu*, Butl. (Eucosmidæ) were found boring in pods of *Bauhinia purpurea*. Larvæ of *Prodenia litura* (Noctuidæ) were found on leaves of *Gnaphalium indicum* and of *Rumex maritimus*.

Epicometis squalida (Rutelidæ) was received in March 1929 from Quetta, where this beetle appeared in large numbers and did considerable damage to peach, pear and apple blossom. *Acrocercops austeropa*, Meyr. was found in November living in some numbers in the larval stage in the flowers of *Bauhinia purpurea*, emerging to pupate on a leaf. The larvæ of *Stomopteryx subsecivella*, Zeller (Lep. Gelechiadæ) a well-known pest of Ground-nut in Southern India, were found mining leaves of *Psoralea corylifolia*. Larvæ of *Margaronia caesalis* were found boring topshoots and buds of *jak* (*Artocarpus integrifolia*). *Perigea capensis* (Noctuidæ) appeared in some numbers on safflower, on which it has not been noticed for several years past. *Agrius grisator*, a Longicorn beetle, emerged from affected *Citrus* stems during December 1928 and January 1929, and it was noted that it emerged during periods of 42°F. minimum temperature.

Life-history studies of the common House Cockroach, *Periplaneta americana*, were continued. This insect seems by no means easy to rear in confinement—at least, under conditions where constant observation is possible—and we have had numerous failures in attempting to breed it. The life-cycle seems to be a long one, probably between one and two years.

An unusual Fruit-fly, *Mellessis eumenoides*, Bezzi, was reared in November from fruits of *Oxystelma esculentum* at Pusa ; the adults proved to be long-lived and passed the cold weather in this stage. Although the larvæ could be collected in some numbers and the adults reared out, the fly seems to be one of those insects which are rarely seen at large, as twenty-five years intensive collecting at Pusa had heretofore only produced one single fly.

In 1918 a very curious Geometrid larva was found at Shillong and a short note on it was published in the *Report of the Third Entomological Meeting*, p. 978, t. 162; as the pupa died when brought to Pusa, it was not possible to identify it. In 1928, when on leave in Shillong, I found two more of these larvæ and obtained pupæ in due course; one of these, brought to Pusa, died (the usual result of bringing living material to the Plains); the other was left with Mr. L. B. Parker, of the U. S. Entomological Service, who kindly reared and sent me the moth, which proved to be *Heteromiza leucogonia*, Hmp. (Plate III, figs. 2 and 3).

Leucoptera sphenographa, Meyr. (Lyonetiadæ) occurred at Pusa in noteworthy numbers during the year. It was abundant in September and again in December 1928 and in March 1929. Normally it is very common about March, large broods being reared on the young *Dalbergia sissu* leaves, but the abnormally large numbers in which it occurred in September and especially in December, are unusual.

Attention has been paid to the life-histories of Indian Microlepidoptera. These comprise the smaller moths, which are as yet little known, their small size enabling them to escape notice although many are serious pests. Amongst the novelties in this group described during the year by Mr. Meyrick in *Exotic Microlepidoptera* are *Microcolona leucosticta*, in fruits of *Psidium* at Coonoor; *M. technographa*, boring shoots of guava at Pusa; *Heterotactis quincuncialis*, on leaves of *Acacia catechu* at Pusa; *Bedellia enthrypta* mining *Porana* leaf at Pusa; *B. annuligera*, mining *Convolvulus* leaf at Pusa, also known from Peshawar and Coorg; *Phyllocnistis triploci* mining *Loranthus* leaf at Pusa; *Lithocolletis epichares*, associated with apple at Shillong; *Epicephala eridopa*, mining *Guazoma* leaf at Pusa; *Acrocercops hormista*, mining *Cedrela toona* leaf at Pusa; *Caloptilia cirrhorotata*, rolling *Dalbergia* leaf at Pusa; *C. isographa*, rolling *Polygonum* leaf at Pusa, also from Coorg and Khasis; *C. thymophanes*, mining and rolling *Odina* leaf; *Bucolarcha geodes*, in pod of *Acacia catechu*, also from Coorg and Natal; *Oedematopoda pyromyia*, associated with bamboo Aphid at Shillong.

Specimens of Crickets attacking young *Casuarina* plants were received from Karwar, N. Kanara. Specimens of Termites were received from Bombay as attacking deal-wood frames of pictures hanging on the walls of the upper storey of a building in Bombay. The sender could not understand how the attack could take place in the upper storey, whilst no sign of termites was to be found on the ground floor. Examination showed the termite to be a species of *Coptotermes*, which usually lives in dead wood of old trees. The winged adults must have flown in to the upper storey, found a suitable nest in the old pictures-frames and proceeded to rear up a colony there, this group of termites not being dependent on access to the ground. Suitable measures were suggested.

Samples of wood treated with "Toritna" were received on 21st April 1928 from the Dry Rot and Fire Prevention Co., London, for test against termites and were buried about a foot underground. On examination on 5th December 1928, two pieces were found to be already attacked vigorously by *Odontotermes assmuthi* and *Microtermes obesi*, and were rejected as failures.

Further experiments on the storage of Food-grains in the presence of Mercury to preserve the grain from insect pests, were carried out during the year. The preliminary results were written up by Mr. G. R. Dutt and sent for publication in the *Agricultural Journal of India*. Briefly, it has been ascertained that Mercury, either in the form of free Mercury or of Mercury-tin amalgam, is quite effective in preventing the breeding of Insect Pests of Food-grains, that the Mercury has no deleterious effect either on the germination of the grain or on the health of the consumers of the grain. Grain so stored should be sunned or at least aired for a couple of hours. Experiments on a larger scale on these lines have been undertaken this year.

The control of Mosquitos on the Pusa Estate has received constant attention, all breeding places being treated as far as possible. An increase of mosquito population in March and April was traced to breeding in about twenty open wells which are used for the supply of drinking water and therefore cannot be oiled. Proposals were made for the permanent screening of these wells. The mosquitos breeding in these wells were mostly *Culex (Culicomyia) pallidithorax* with lesser numbers of *Culex fatigans* and of another species as yet unidentified. It has been claimed that the presence of a minute quantity of ammonia will prevent mosquito-breeding; experiments, however, showed that this treatment was inapplicable owing to the hardness of the water, the ammonia added being at once precipitated as ammonium carbonate. Holes in trees and bamboos were filled in before the commencement of the Rains to prevent breeding of *Stegomyia* and other mosquitos. To reduce cost of treatment by oiling, waste kerosene-oil from the Power House was tried but not found to be effective, unless mixed with an equal quantity of kerosene.

Lucilia pulchra, Wied, (*Muscidae*), was successfully reared from dead meat. Eggs were laid at the end of November and the larvæ continued to grow slowly in December, hibernated during the colder weather in January and the first half of February, pupated in the latter half of February, and emerged early in March.

A large Mygalomorph Spider was received from the Civil Surgeon, Jaunpur, U. P., with the information that it was reported to have bitten and caused the death of a child. There seem to be few cases on record of the effects of the bite of these large Spiders in India, although they are of not uncommon occurrence.

Mr. P. V. Isaac, Second Entomologist (Dipterist), has continued his work on Indian Tabanidæ, especially studies of life-histories. Egg-masses of *Hæmatopota roralis*, Fb., and of *Tabanus speciosus*, Ricardo, were collected at Coimbatore in August and reared at Pusa to the adult stage. It was noted that *T. speciosus* covers its egg-mass with long, flat, chitinous bodies which somewhat resemble the eggs but differ in being longer, darker, empty and flat; these bodies are cemented over the egg-mass by a chalky substance.

Mr. Isaac has made some experiments with larvacides and with baits to attract female mosquitos to lay eggs. Potato decoction, after standing in an earthen pot for one night, had a considerable attraction for egg-laying *Culex fatigans*, a common breeder in filthy water; the original bait, kept in the garden of an occupied house, continued to be attractive for eleven days, during which period an average of 12.7 egg-masses per night were found in the baited pot, whereas a pot with well-water kept as a control had only an average of 0.3 egg-masses per night. In practical use, however, such measures do not succeed, for it has been our experience in the past that water-receptacles put out to trap mosquito egg-laying (even short lengths of bamboo tied up in trees to trap *Stegomyia*) are invariably stolen sooner or later—usually sooner.

IV. BEES AND LAC.

Apiculture. Numerous inquiries were received and information and assistance given as far as possible. There seems to be a considerable demand for hives, foundation-combs and similar apparatus. Foundation-comb for *Apis indica* can be made at Pusa if we can procure sufficient pure beeswax to make it from, but it seems impossible to buy pure beeswax anywhere in India unless it can be got from remote tracts where it has been collected. Some wax sent to us from the Punjab for comb-making was found to be so badly adulterated that it was too brittle to make comb at all.

Lac. The emergence of Lac larvæ on different host-plants took place on the following dates.

Kusum (Schleichera trijuga)—

- (1) 17 September 1928.
- (2) First week of April 1929.

Palas (Butea frondosa)—

- (1) 5 October 1928.
- (2) Nil.

Ber. (Zizyphus jujuba)—

- (1) 10 October 1928.
- (2) 22 June 1929.

Owing to deterioration of the crop on account of Chalcid parasites, the second emergence of the *Palas* lac was a total failure.

Requisitions for brood-lac were complied with as far as possible.

During the year the Lac area was fenced in in order to conserve the lac-bearing trees.

V. INSECT SURVEY.

Collections were sent for identification to the following specialist whose help is gratefully acknowledged :—

1. Coccidæ, Saldidæ, Chalcidæ, Acrididæ and Gryllidæ to the Imperial Bureau of Entomology.
2. Sphingidæ to Dr. K. Jordan, Tring.
3. Noctuidæ to Miss Prout.
4. Geometridæ to Mr. L. B. Prout.
5. Monophlebus to Mr. E. Ernest Green.
6. Aphididæ to Mr. Laing.
7. Culicidæ to Captain Barraud.
8. Scolytidæ to Dr. Beeson, Dehra Dun.
9. Tenebrionidæ to Mr. Gardner, Dehra Dun.

Specimens received from numerous correspondents for identification were examined and named as far as possible.

The care of the collections of insects takes yearly more time and attention from the staff as these collections continue to expand and hence, of course, become more valuable for reference by Provincial workers. Many of the groups of Insects contain specimens which have been identified by specialists who are now dead; such specimens can never be replaced and their preservation for the information of future workers on Indian Insects is a matter of prime importance. The provision of Cabinets scarcely keeps pace with the growth of the collection, the majority of which is still kept in old storeboxes which are very unsatisfactory in use.

The identification and arrangement of Tabanidæ was continued. The Calliphorine Muscids and Asilidæ have also been gone over and the whole collection of Microlepidoptera has been rearranged and expanded.

VI. CATALOGUE OF INDIAN INSECTS.

A catalogue of the Indian Carabidæ was received from Mr. H. E. Andrewes and sent to Press during the year. Catalogues of other groups, especially of the Microlepidoptera, have been kept up to date at Pusa as new genera and species have been added to the Indian list, but press of other work has prevented their being written out for publication.

VII. PROGRAMME OF WORK FOR 1929-30.

Major.

This will follow generally on the lines of work of the current year and will include general investigations of crop pests and especially of the pests of sugarcane, rice and cotton, of fruit-trees and stored grains.

Minor.

Results in various lines of work require to be written up and published as far as possible. New insecticides and insecticidal methods will be tested as occasion arises. Systematic work will be carried out with our resources and the help of specialist correspondents. The Catalogue of Indian Insects will be proceeded with. Advice and assistance will be given as far as possible to Provincial Departments and to all inquirers on entomological subjects.

VIII. PUBLICATIONS.

The following publications, either prepared by the Pusa staff or founded in whole or in part on material sent from Pusa, have actually been issued during the year ended 30 June 1929 :—

- ANDREWES, H. E. . . . Carabidæ Part I, Carabinae. (*Fauna Brit. India Series.*)
- FLETCHER, T. BAINBRIGGE A remarkable Lepidopterous Pupa from India. (*Proc. Ent. Soc. London* III, 24 fig.)
- FLETCHER, T. BAINBRIGGE A Veterinary Entomology for India, Part VI. (*Jl. Anim. Husb. Ind.*, II, pp. 64-73, Plates A-B, figs. 1 to 5.)
- AND SEN, S. K. A Veterinary Entomology for India, Part VII. (*Jl. Anim. Husb. Ind.* II, pp. 101-122, figs. A-F, 4-17; Oct. 1928.)
- A Veterinary Entomology for India, Part VIII. (*Jl. Anim. Husb. Ind.*, III, pp. 17-24, 17 figs. May 1929.)
- MEYRICK, E. . . . Exotic Microlepidoptera, Vol. III, parts 13-17.

REPORT OF THE IMPERIAL AGRICULTURIST.

(WYNNE SAYER, B.A.)

I. CHARGE.

Mr. G. S. Henderson, N.D.A., N.D.D., Imperial Agriculturist, remained in charge of the Agricultural Section from 1st July, 1928, to 4th April, 1929, when he proceeded on six months' leave. Mr. Wynne Sayer, B.A., Offg. Imperial Agriculturist, took over charge of the Agricultural Section on 5th April, 1929. Mr. Arjun Singh Maan, L.Ag., Assistant to the Imperial Agriculturist, remained in charge of the agricultural operations throughout the year. Mr. L. S. Joseph held charge of cattle-breeding from 1st July to 2nd August, 1928, and again from 22nd August, 1928, to 14th February, 1929. Mr. S. M. Jamaluddin, Second Cattle Superintendent, remained in charge of the cattle-breeding operations from 3rd to 7th August, 1928, and again from 15th February to the end of the year.

II. TOURING.

The Imperial Agriculturist attended the meeting of the Advisory Board of the Lac Institute to consider the necessity of an agricultural and industrial survey of the lac situation. He visited the Dacca farm and made suggestions regarding fodder crops, silage-making and silos. He also visited Poona regarding the agricultural affairs in Sind and advised on the question of rotations for the Nira Canal area. He judged the live stock at Ahmedabad and visited the Veterinary Institute at Muktesar to advise on cattle policy and general agriculture. In the Punjab he toured in connection with the completion of the Bara Reclamation Farm and also in Sind in tracts to be irrigated by the Rohri-Hyderabad Canal.

The Officiating Imperial Agriculturist toured to Calcutta to discuss the threshing problem with Messrs. Jessop & Co. and make suggestions regarding the Vickers tractor. He inspected the general cultivation and plantation work at the Lac Institute at Namkum. He visited the farm at Kanke and saw the herd records; sugarcane Co. 290 was noted as doing excellently under Ranchi conditions.

III. ADVICE AND PUBLICATIONS.

Advice by correspondence was given to an increasing number of enquirers from Government and private bodies on a large range of agricultural subjects. One hundred and sixty visitors were shown round the farm and breeding herd during the year.

Four Bulletins Nos. 91 to 94 were published on Agricultural Implements and Machinery at Pusa.

IV. TRAINING.

Four students of the Animal Husbandry and Dairying course, who were admitted in the middle of April 1928, completed the portion of their training at Pusa in the middle of July 1928.

V. SEED DISTRIBUTION.

The demand for improved seed continued to increase. Indents were received from all parts of India and Burma and were complied with as far as possible. Those whose indents could not be filled were advised on other sources of supply. Four hundred and fifty-three maunds of wheat, 304 maunds of oats, 29 maunds of fodder and miscellaneous crops were distributed, and 1,602 maunds of sugarcane were sent out to growers.

VI. FARM CULTIVATION.

Season. The monsoon rainfall for the season was markedly heavier than that of the previous year, 54.02 inches being registered as against 37.17 inches and rain being recorded on 87 days. In August, following heavy rain on the 3rd and 4th, when 15 inches fell, the river rose and the entire area west of the main bund was submerged resulting in the total loss of all crops except the cane. A fall of 6.21 inches in October benefited the late sown pulses, but put the *rabi* sowings back. On the 11th March a heavy shower lodged most of the oat and wheat crops causing considerable difficulty in harvesting. The season, in short, while being very bad for *kharif* and cane crops, gave an excellent *rabi*.

Crop Results.

Arhar. This crop is generally sown mixed with maize which is harvested in October leaving the *arhar* (*Cajanus indicus*) to grow on during the cold weather. Sixty-nine acres were sown, out of which the crop on 21.43 acres was destroyed by flood. An area of 47.57 acres was harvested, the average yield being 12.25 md. per acre. One of the B. S. varieties gave as high an yield as 14.35 md. per acre.

Maize. As stated above, this crop is generally sown mixed with *arhar* and is harvested for cobs in October. The yield per acre was 12 md. when grown mixed with *arhar*. One hundred and twenty acres were sown with maize for silage out of which 93.83 acres were flooded. The crop on the rest of the land was very poor on account of heavy rain.

Oats. The oat crop was excellent. The average outturn per acre for an area of 240 acres was 20.53 md., as against 16.7 md. last year.

The highest outturns were 26 maunds and 24 maunds from Harpur Jhilli (21 acres) and Chhionia (27 acres) respectively of oats following a pulse crop grazed off by cattle.

Wheat. Three standard Pusa varieties were grown in Harpur Jhilli and Brickfield. The yields were as follows :—

									Md. per acre.
Harpur Jhilli :—									
Pusa 4	.	.	.	.	.	.	.	.	12.65
Pusa 12	.	.	.	.	.	.	.	.	16.87
Pusa 52	.	.	.	.	.	.	.	.	17.67
Brickfield :—									
Pusa 52	.	.	.	.	.	.	.	.	20.12

The average outturn per acre from 38 acres was 16.78 md.

Berseem. The *dhab* or low river bank area has now become an independent unit utilized solely for growing green fodder under irrigation for the breeding herd. It is controlled by two pumping sets of 5 and 3 cusecs respectively. Two crops of green fodder are raised from this area each year : berseem in the cold weather being followed by maize sown with a pulse in the early hot weather. In 1928 berseem sowing was started on 1st October and 121 acres were sown by the middle of November, the seed-rate varying from 26 to 30 lb. per acre. The first grazing started on 22nd November and a full supply of fodder for grazing and cutting was available up to the 16th May. 23,500 md. of berseem was cut over and above the grazing. The third flush was very heavy and as the weather was not favourable for making hay, as a first experiment the surplus was placed in silos. These were filled about the middle of March and when opened 8 weeks later, the silage was found to be very good and was greedily eaten by cattle. There was slight wastage percentage at the top, but this will be lessened when larger pits are used.

Berseem was followed by early maize sown with *meth* (*Phaseolus aconitifolius*). By the system of rotation sowing, this became available directly the berseem was over. About 8,000 md. of surplus maize was siloed and the balance stands for green fodder till the end of July.

Peas. Two varieties of field peas P. F. 1A and P. F. 2A were grown on a field scale and an yield of 16 md. and 13 md. per acre, respectively, was obtained.

Sugarcane. The main experimental work on cane is done at the New Area, the ten-acre block on the main farm being devoted solely to the testing of selected varieties under estate conditions in a general rotation. In the New Area the grading of block No. 1 was finished and three main blocks are now available for cane work. This area is controlled by irrigation which is used for berseem and other leguminous crops grown to maintain the fertility. A certain area in the Nursery is also irrigated

for the purpose of bringing along new canes, but the main area under cane as usual is treated as an unirrigated crop throughout the year. The main cane crop stood on Block No. 1 and was to a certain extent disappointing as a portion of this block was distinctly *usar* and this put Co. 213 back badly, the average yield being below Co. 210. The combination of lighter rainfall and land which is not in first class heart seems to affect the tonnage of Co. 213 in a very marked manner compared with Co. 210, and the Secretary, Sugar Bureau, is planning a set of experiments to throw further light on this most important point.

Levelling off the three main blocks is now complete, and when the land settles down to a uniform fertility, we shall have available for cane work three blocks representative of light, heavy and medium soils together with a certain portion of waterlogged area suitable for further tests on the Co. 205 type of canes.

Before going further, it is as well to note that a definite level of fertility has not yet been achieved and in consequence experiments on acre plots of single varieties frequently give inconclusive results. The close inter-stripping of all important variety tests will start this year.

The varieties under trial were analysed as usual and the crop harvested during the cold weather.

The following experiments were carried out :—

- I. October *versus* February planting.
- II. Tonnage experiment.
- III. Manurial experiments.
- IV. Variety tests, Estate scale.
- V. Variety tests, Nursery.
- VI. Mosaic experiments in collaboration with the Imperial Mycologist.

I. The results of *October versus February planting* are given below and it will be seen that in a normal year in average soil with a late cane, the advantage lies distinctly with the February planted crop.

In the matter of the new early ripening canes, a considerable advantage has been found in October planting and this practice is now standard with all such canes and seed distribution of these canes is now made in October only. When small areas of early canes are kept till February, jackal damage becomes so extensive that the entire crop is rendered unfit for seed and in the past considerable delay in the experimental work has been experienced owing to these causes.

	Md. per acre.
Co. 210 October	292
Co. 210 February	495
Co. 213 October	326
Co. 213 February	416

II. *Tonnage experiment.* In collaboration with the Imperial Mycologist, this experiment was laid down to test the percentage variation in yield of cane from plot to plot in case of small size plots. Ten acres were laid down and were cropped with Co. 213. The crop was planted in February 1928 and was uniformly treated throughout the season and was harvested in one-tenth acre measurements. The yields were weighed and the results are as follows.

Result of the 10-acre tonnage experimental plots, 1928-29.

(In maunds.)

Standard deviation : 11.9 md.

NORTH.

WEST.	16.75	33.50	34.50	37.12	31.75	36.00	55.00	56.50	61.25	64.50	EAST.
	18.50	41.75	37.50	33.25	27.75	54.00	42.50	55.00	58.87	66.25	
	17.00	30.25	37.00	33.25	37.75	44.00	45.37	54.25	59.25	65.75	
	24.00	37.50	57.75	28.00	27.75	46.50	48.75	49.00	44.00	62.50	
	32.60	437.00	51.75	53.87	44.50	41.00	54.00	46.25	45.50	54.75	
	16.50	30.75	44.25	43.25	38.00	49.00	47.50	49.25	48.50	45.25	
	9.00	36.00	39.75	42.00	37.75	45.00	43.00	42.75	41.25	43.75	
	12.50	46.75	65.00	52.25	38.00	48.00	51.50	47.00	46.25	51.25	
	24.50	30.50	34.50	32.62	50.00	48.00	52.00	53.75	53.75	45.62	
	25.50	33.75	37.00	46.75	51.25	49.75	56.50	50.75	44.00	50.00	

SOUTH.

III. *Manurial experiments.* These experiments were carried out on an area of 10 acres on four standard varieties of sugarcane with mustard cake, *mahua* cake, nitrate of soda and sulphate of ammonia. The crop was planted in February 1928. The results are given below :—

Variety of cane	Mustard cake $\frac{1}{2}$ ton per acre	<i>Mahua</i> cake $\frac{1}{2}$ ton per acre	Nitrate of soda 2 md. per acre	Sulphate of ammonia 2 md. per acre
	Yield per acre.			
	md.	md.	md.	md.
Co. 205 . . .	806	450	1,000	822
Co. 210 . . .	652	614	663	670
Co. 213 . . .	477	361	500	464
Co. 214 . . .	460	476	406	350

Calcium cyanamide applied to Co. 213 at 4 md. per acre yielded 371 md.

The varieties under test were the standard varieties grown in North Bihar.

The results show the values of the manures on each separate cane.

The varying fertility of the land prevented any comparison of the tonnage figures of the different canes.

IV. *Variety tests on an estate scale* were conducted on a ten-acre strip in Brickfield No. II, the object being to test canes in a definite rotation under estate conditions. The varieties were :—

B. S. 3, 4, 5 and 11.

Co. 248, 270, 280, 287, 290, 294, 296, 297, 298, 299, 300, 301, 302, 303, with check plots of Co. 205, 210, 213 and 214.

Unfortunately this cane was under 4 ft. of water for some time and as the test was not laid out to include such points, the results are inconclusive and the whole experiment will be repeated this year. An interesting point arising from this test was the fact that under such conditions Co. 205 was only 5th, being beaten by four other canes including Co. 213. Co. 290 was the last of 23 canes under trial.

Outturn of sugarcane crop in Brickfield No. II during 1928-29.

Serial No.	Varieties	Area in acres	Outturn per plot		Outturn per acre	REMARKS
			md.	sr.	md.	
1	Co. 213 . . .	0.38	162	0	426	Cut by the Imperial Entomologist for insect examination while young.
2	„ . . .	0.15	..	..	..
3	Co. 214 . . .	0.07	12	26	181	
4	B. S. 3 . . .	0.23	108	19	471	
5	B. S. 4 . . .	0.59	199	20	338	
6	B. S. 5 . . .	0.30	98	34	329	
7	B. S. 11 . . .	0.38	157	31	415	
8	Co. 248 . . .	0.98	239	13	244	
9	Co. 270 . . .	1.05	418	26	398	
10	Co. 280 . . .	0.15	34	26	231	
11	Co. 287 . . .	0.84	275	33	328	
12	Co. 290 . . .	0.84	176	27	210	
13	Co. 296 . . .	0.25	53	25	214	
14	Co. 297 . . .	0.13	36	16	280	

Serial No.	Varieties	Area in acres	Outturn per plot		Outturn per acre	REMARKS
			md.	sr.	md.	
15	Co. 298 . . .	0.15	34	1	226	
16	Co. 299 . . .	0.30	89	2	296	
17	Co. 300 . . .	0.08	19	20	343	
18	Co. 210 . . .	0.15	49	15	329	
19	Co. 301 . . .	0.98	318	5	324	
20	Co. 302 . . .	0.80	257	15	322	
21	Co. 303 . . .	0.53	274	8	517	
22	Co. 294 . . .	0.15	57	33	385	
23	Co. 205 . . .	0.15	60	39	406	

V. Nursery work. The following varieties were planted in the Nursery and carefully observed throughout their period of growth for agricultural habit :—

B. S. 1, 2, 6, 7, 8, 9, 10, 12, 13, 14 and 15.

Co. 223, 282, 294, 295, 304, 305, 306, 307, 308, 310, 311, 312, 313, 315, and 316.

B. H. 10 (12).

P. O. J. 2696, 2714 and 2727.

Co. 223, Co. 304, B. S. 3 and B. S. 5 are of the Co. 210 type and are being tested against this cane. To-date Co. 223 and Co. 210 are best. Co. 304 lacks tillering and B. S. 3 and B. S. 5 are not quite so forward in growth.

Co. 281 has been replanted and every endeavour is being made to get this cane forward, as with a purity of 93 in the first week in December and a final sucrose in juice of 19.28 together with all the advantages of heavy tonnage, rapid germination and a good agricultural habit—this cane would put factory yields up to 11 per cent. if we could establish it. To-date it is rapidly improving and looks like making a stand.

Co. 280, Co. 282, Co. 308 and B. S. 9 are the usual combination of high sucrose and very moderate agricultural habit. B. S. 9 is definitely too thin for free growers.

Co. 287 and Co. 290 are being grown on. They are both types of the cane required for North Bihar optimum conditions. Co. 290 requires to be planted in October, and along with all the rest of such early canes,

should not be allowed to stand on to February for seed. These two canes have been planted out on various areas throughout North Bihar to test their suitability to conditions outside.

Co. 235, Co. 245 are now being multiplied for replacing Co. 205. Estate tests will be undertaken with these three canes on low land next season.

Co. 205 has now been definitely rejected by the mill as unsuitable. It is a wonderful tonnage cane for its particular area, but it is necessary to consider the mill side of the question.

Co. 236, Co. 311, B. S. 4 and 11 are also thin canes of a *barani* (rain-fed) type, which, despite high sucrose, are hampered by short tonnage.

Co. 237, 238, 239, 300, 312 and 313 represent a batch of canes rather than Co. 213 and Co. 210. They are medium canes just short of Co. 213. Co. 238 is a very rapid germinator. They all are absolutely sweet in sucrose, but whether they will taller to give the tonnage has to be seen. I regard them as a very promising set.

Co. 301, 302 and 303 are strong tillers with good growth and are also high in sucrose, but Co. 303 lodges badly and the other two have to prove themselves under estate conditions.

Co. 300 and 310 do not appear to resist drought sufficiently and are in consequence backward.

Co. 307, B. S. 14 and B. S. 15 do not appear to be canes which will stand unirrigated conditions well.

P. O. J. 2496 which looks a 'regellan' type will be tried out next year to see if this characteristic maintains itself under estate conditions.

We have now reached a stage in the cane investigation at Pusa where it is essential that we should retrace our steps and consolidate the position. The data obtained by the Secretary, Sugar Bureau, during the last 3 years point to the fact that we are not altogether in the right lines for the tract and experiments are now being laid down to determine this point. The desire for tonnage on the part of the grower and the natural demand for sucrose in the mill coupled with the impossibility of controlling the cultivation of any cane which sacrifices the second for the first make it imperative that our cane work should proceed on extremely rigid lines marked out by the limits within which we have already found success. To advance too near the irrigated line for the sake of extra sucrose and tonnage is to lose all that has been gained up to date in the course of our bad season, while to keep to high sucrose for tonnage *barani* canes is simply to alienate the grower from all our work. In North Bihar with its considerable variation in rainfall, all cane improvements must be based on long term experiments and experience.

VI. *Mosaic experiments.* These experiments were, in collaboration with the Imperial Mycologist, carried out in Gonda field. Five healthy plots and five plots sown from fully infected seed were laid down, each

of one-fourth acre, and received uniform standard treatment. The results are given below :—

Plot No.	Varieties	Healthy or Mosaic	Area	Outturn per plot	Outturn per acre
			acre	md.	md.
1	Co. 213	M	0.25	103	412
2	„	M	0.25	103	413
3	„	M	0.25	94	377
4	„	M	0.25	87	347
5	„	H	0.25	109	437
6	„	H	0.25	112	447
7	„	H	0.25	111	445
8	„	H	0.25	75	298
9	Co. 205	H	0.25	137	549
10	„	M	0.25	143	573

This experiment will be continued in season 1929-30.

The cost of growing cane. Rs. 100 roughly is set as the cost figure for one acre of cane under standard cultivation and manuring. All manurial experiments are based on the cost which represents the maximum likely to be spent per acre by any grower. Below is given the details of the cultivation costs of Block No. 1, 31.23 acres under cane in 1928-29 in New Area :—

	md.
Total yield	13,799
Average yield	441 md. per acre
	Rs.
Preparation : 5 ploughings and 6 harrowings	10.7
Planting	8.3
Interculture, 8 hoeings, 1 ridging	9.8
Manure, 14 md. oil cake, 2 md. super	50.54
Seed 65 md. at mill rate	24.36
Harvesting and incidental charges	1.1
TOTAL	104.8

costing a shade under As. 4 per maund.

The crop planted in October 1928 and February 1929 is making excellent progress and will be dealt with in next year's report.

VII. FIELD EXPERIMENTS.

I. *The permanent manurial and rotation experiments* were continued in C. Block, Punjab field, as before.

The results are given below, the average figure for the preceding 20 years being given below those for the year under report :—

Results of Permanent Manurial and Rotation Experiments for 1928-29.

Plot No.	Treatment	A-SERIES			B-SERIES		
		Maize grain per acre in lb.	Arhar grain per acre in lb.	Barley grain per acre in lb.	Maize grain per acre in lb.	Oats grain per acre in lb.	Peas grain per acre in lb.
1	No manure	213	1,076	..	353	509	..
		676	947	..	510	482	..
2	Farmyard manure to supply 10 lb. nitrogen per acre.	345	1,248	..	427	829	..
		825	948	..	710	638	..
3	Farmyard manure to supply 20 lb. nitrogen per acre.	452	1,412	..	764	904	..
		985	988	..	832	740	..
4	Farmyard manure to supply 30 lb. nitrogen per acre.	534	1,429	..	953	1,232	..
		1,096	1,003	..	905	829	..
5	Rape cake to supply 20 lb. nitrogen per acre.	501	1,273	..	723	739	..
		948	894	..	795	559	..
6	Sulphate of ammonia to supply 20 lb. nitrogen per acre.	328	1,166	..	493	517	..
		599	890	..	504	420	..
7	Sulphate of potash to supply K ₂ O as in farmyard manure No. 3.	287	1,125	..	443	509	..
		554	750	..	428	410	..
8	Superphosphate to supply P ₂ O ₅ as in farmyard manure No. 3.	452	1,133	..	862	953	..
		923	791	..	783	698	..
9	Sulphate of potash to supply K ₂ O and super to supply P ₂ O ₅ as in farmyard manure No. 3.	452	1,141	..	599	920	..
		864	704	..	753	699	..
10	Sulphate of ammonia to supply nitrogen, sulphate of potash to supply K ₂ O and super to supply P ₂ O ₅ as in farmyard manure No. 3.	599	1,068	..	780	1,109	..
		984	709	..	990	755	..
11	No manure or leguminous crop	148	..	361	213	493	..
		492	..	313	506	439	..
12	Green manure in a cereal rotation	402	..	460	..	714	..
		844	..	376	744	642	..
13	Deep rooted leguminous crop in a cereal rotation.	320	920	..	526	476	..
		598	742	..	519	436	..
14	One deep and one shallow rooted legume in the rotation.	411	928	..	542	460	20
		636	639	..	582	329	93
15	Green manure and leguminous crop in the rotation.	821	953	..	..	920	..
		1,013	687	..	774	664	..
16	Green manure and superphosphate to supply P ₂ O ₅ as in farmyard manure No. 3.	1,133	1,166	..	..	2,152	..
		1,367	762	..	1,242	1,523	..

In the year under report the green manure and super plot continued to give the highest outturn of oats.

The average yield of the maize-*arhar* combination is superior to that of the maize-oats.

The yield of peas in plot 14 has reached vanishing point, 20 lb. against 12 maunds normal. Plot No. 10 is slightly better this year than plot No. 3 with which it is in comparison.

II. *Varietal tests of arhar varieties* were carried out in B block, Punjab field, and the Imperial Economic Botanist's *arhar* variety No. 163 (G) was grown in comparison with those on the Pusa farm. The crop was sown alone in June 1928. The Farm variety P. F. No. 4 gave the highest outturn.

Serial No.	Crop	Variety	Average yield per acre
			lb.
1	Arhar	P. F. 1 Pusa Farm	1,560
2	"	P. F. 2 " "	1,866
3	"	P. F. 4 " "	2,211
4	"	P. F. 6 " "	1,616
5	"	P. F. 10 " "	1,737
6	"	No. 163 (G), I. E. B.	1,952

III. *The wilt manurial experiments* were continued in North Pangarbi field with the following results. The maize plants were cut green as their cobs were badly damaged by jackals when they were young.

Results of wilt manurial plots in North Pangarbi for 1928-29.

Plot No.	Treatment per acre	A-SERIES		B-SERIES	
		Maize grain per acre	Arhar grain per acre	Maize grain per acre	Arhar grain per acre
		lb.	lb.	lb.	lb.
1	Check— P_2O_5 60 lb. . . .	5,338	236	5,338	380
2	P_2O_5 20 lb. . . .	4,927	359	3,696	647
3	Check— P_2O_5 60 lb. . . .	5,338	513	3,285	421
4	$MgSO_4 \cdot 7H_2O$ 150 lb., P_2O_5 60 lb.	4,927	421	3,285	287

Plot No.	Treatment per acre	A-SERIES		B-SERIES	
		Maize grain per acre	Arhar grain per acre	Maize grain per acre	Arhar grain per acre
5	Check— P_2O_5 60 lb. . . .	5,133	370	3,490	185
6	$MgSO_4 \cdot 7H_2O$ 300 lb., P_2O_5 60 lb.	3,285	318	2,874	226
7	Check— P_2O_5 (Bonemeal) 60 lb.	2,464	523	2,464	554
8	$Fe_2(SO_4)_3$ 150 lb., P_2O_5 60 lb. .	2,258	421	2,464	523
9	Check— P_2O_5 60 lb. . . .	2,464	523	2,464	565
10	$Fe_2(SO_4)_3$ 150 lb., P_2O_5 60 lb. .	3,696	493	2,464	544
11	Check— P_2O_5 60 lb. . . .	2,464	534	4,106	616
12	$Fe_2(SO_4)_3$ 150 lb., P_2O_5 60 lb. .	2,464	636	3,284	749
13	Check— P_2O_5 60 lb. . . .	3,490	862	3,284	821

These experiments have now been discontinued under the instructions of the Imperial Mycologist.

IV. *A green-manuring experiment* was carried out for the Imperial Agricultural Chemist in North Pangarbi field. Details are shown below :—

Plot No.	Treatment	Yield of oats in lb. per acre
1	No manure	893
2	Green-manured with sann-hemp alone grown outside the plot	785
3	Superphosphate alone @ 50 lb. P_2O_5 per acre . . .	523
4	Green-manured with sann-hemp grown outside the plot and with super-phosphate @ 50 lb. P_2O_5 per acre	1,001
5	No manure	770
6	No manure	708

Again the green manure and superphosphate plot gave a markedly high outturn of oat grain.

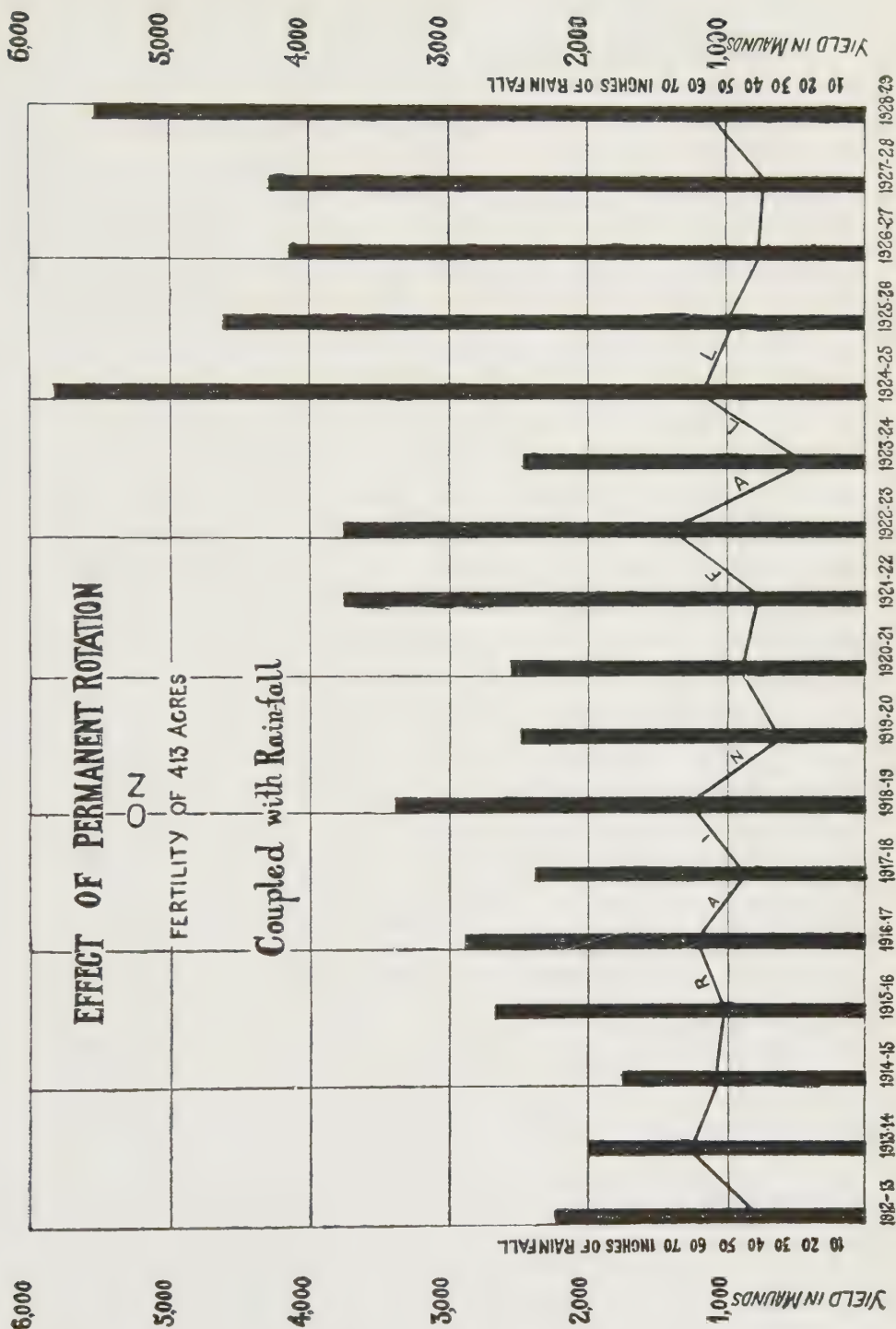
V. *The general fertility experiment* was continued as usual on an area of 413 acres according to the rotation mentioned before. Crop results for the last 17 years are as follows :—

Yield of 13 fields (413 acres) for the last 17 years.

Year	Annual rainfall	Oats and other cereals	Maize	Pulses	Total grain	Green stuff for fodder and silage
	Inches	md.	md.	md.	md.	md.
1912-13 . .	41.26	2,210	522	894	3,626	16,301
1913-14 . .	61.74	1,997	200	1,100	3,297	11,513
1914-15 . .	54.88	1,749	534	704	2,987	14,427
1915-16 . .	51.37	2,669	884	701	4,254	36,903
1916-17 . .	59.67	2,897	670	932	4,499	31,971
1917-18 . .	45.54	2,376	1,276	1,010	4,662	30,893
1918-19 . .	60.19	3,386	559	1,037	4,982	30,735
1919-20 . .	32.73	2,479	1,064	719	4,262	31,624
1920-21 . .	44.33	2,542	766	1,073	4,381	33,359
1921-22 . .	39.82	3,754	1,267	1,132	6,153	34,492
1922-23 . .	65.78	3,752	496	941	5,189	23,021
1923-24 . .	24.88	2,448	988	1,100	4,536	29,146
1924-25 . .	57.00	5,816	467	1,234	7,517	20,936
1925-26 . .	48.67	4,611	343	1,030	5,984	22,906
1926-27 . .	38.74	4,131	540	512	5,183	21,293
1927-28 . .	37.17	4,283	957	649	5,889	26,459
1928-29 . .	54.02	5,519	351	1,023	6,893	11,593

The bad effect of the season on the *kharif* crop is marked by the shortage of green fodder which is over 50 per cent. less than last year.

VI. Two acres of Pusa 4 (smooth-glumed) were sown in B Block, Punjab field, for the Imperial Economic Botanist, the results of which are given below along with other standard varieties of wheat grown in Punjab D Block.



Serial No.	Wheat variety	Average yield in lb. per acre	REMARKS
1	Wheat Pusa 4	1,038	Smooth glumed.
2	„ „ 4	865	Hairy glumed.
3	„ „ 12	1,103	
4	„ „ 52	988	

VII. Below is given the yield of *arhar* for the wilt experiment in Punjab field, D Block, for the Imperial Mycologist during 1927-28.

Plot No.	Variety	Yield in lb. per acre	Treatment
10 D	<i>Arhar</i> No. 1 treated seed	599	Superphosphate @ 4 cwt. per acre.
11 D	„ „ „ „	969	No manure.
25 D	„ „ „ „	1,503	Super @ 4 cwt. per acre.
26 D	„ „ „ „	1,454	No manure.
27 D	„ „ „ „	1,199	Super @ 4 cwt. per acre.
28 D	„ „ „ „	977	No manure.

VIII. *Fodder pulses.* The value of the leguminous pulses has been fully established as a green fodder crop for live-stock. They were again tried on a plot scale for yields both of grain and fodder. The results are as follows :—

Yield of seed of kharif pulses in lb. per acre.

Serial No.	Name of pulses	Average yield of seed in lb. per acre	Highest yield of seed in lb. per acre
1	Soybean No. 1, yellow (<i>Glycine hispida</i>)	1,199	1,232
2	Soybean No. 2, Chocolate (<i>Glycine hispida</i>)	1,453	1,492
3	Meth (<i>Phaseolus aconitifolius</i>)	1,119	1,306
4	Guar (<i>Cyamopsis psoralioides</i>)	833	920
5	Velvet bean	599	640
6	Cowpeas (<i>Vigna Catjang</i>)	599	624

Yield of green fodder for kharif pulses.

Serial No.	Name of pulses	Average yield of green fodder in lb. per acre	Highest yield of green fodder in lb. per acre
1	Soybean No. 1, Yellow (<i>Glycine hispida</i>) .	6,734	7,227
2	Soybean No. 2, Chocolate (<i>Glycine hispida</i>) .	9,567	9,609
3	Meth (<i>Phaseolus aconitifolius</i>)	5,255	6,406
4	Guar (<i>Cyamopsis psoralioides</i>)	5,964	7,309
5	Velvet bean	7,063	7,720
6	Cowpeas (<i>Vigna Catjang</i>)	7,842	8,869

Seed Selection. All the staple crops on the Farm are now sown from selected seed from strains maintained on the Pusa Farm.

The best results so far have been obtained with maize, *arhar*, chillies, oats and peas.

VIII. IMPLEMENTS AND MACHINERY.

Tractors. A 15-30 H.P. International tractor was purchased in January 1927 and started work in April 1927. It has been used for the past two years for both cultivation and belt work and has worked with complete success. No breakdowns have been experienced, and during this period, eight sparking plugs at a cost of Rs. 28 and two fan belts costing Rs. 26-8 have been the only replacements required.

Ransome's 3-furrow mould board plough, the same firm's Orwell cultivator with 11 tines, the Roderick Lean disc harrow (28 discs) and a Cambridge roller have been worked by this tractor. As we use a 'henga' behind the cultivator and disc harrow, the capacity of the tractor has been fully tested. Our Cambridge roller is too small for this tractor which could have pulled another abreast and thus halved the cost of rolling.

On belt work, types B & E International Silage Cutters, 20-28 Case Thresher, Ransome's 30" Consul Thresher and three and four roller cane mills have been successfully operated. Full cost details of the work are given below :—

Statement showing output, consumption and cost of cultivation of McCormic Deering Tractor for 1927-28 and 1928-29.

Year	Work- ing hours	SUMMARY OF WORK DONE FOR 1927-28 AND 1928-29								Total Acres
		PLOUGHING		DISC HARROWING		GRUBBING		ROLLING		
		Hours	Acres	Hours	Acres	Hours	Acres	Hours	Acres	
1927-28 & 1928-29.	614.6	73.5	63.5	245.9	420.5	202.3	324.5	93	116.4	924.89

Acres per hour.

Ploughing	Disc harrowing and hengaing	Grubbing and hengaing	Rolling
0.86	1.71	1.60	1.25

Consumption.

Year	Working hours	FUEL KEROSENE OIL AND PETROL		ENGINE AND GEAR OIL		GREASE		WASTE	
		Total gallons	Per hour gallons	Total gallons	Per hour gallons	Total lb.	Per hour lb.	Total lb.	Per hour lb.
1927-28 & 1928-29.	614.6	K. Oil 1074.25 Petrol 46.5	K. Oil 1.74 Petrol 0.07	107.07	0.17	86.5	0.14	0.35	0.05

Cost.

Year	Working hours	ANALYSIS OF TOTAL COST					
		Labour	K. Oil and petrol	Lubricants, etc.	Spare parts	Total	Per hour
		Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
1927-28 & 1928-29.	614.6	176 10	869 11	270 13	62 14	1,380 0	2 3 11

Cost per acre.

Ploughing	Disc harrowing and hengaing	Grubbing and hengaing	Rolling
Rs. A. P.	Rs. A. P.	Rs. A. P.	Rs. A. P.
2 9 10	1 5 0	1 6 6	1 12 10

Belt work.

Hours of work	Kerosine oil consumed	Kerosine oil per hour	Petrol consumed	Petrol per hour	Lubricat- ing oil consumed	Lubricat- ing oil per hour	Total expenses	Expenses per hour
	Gallons	Gallons	Gallons	Gallons	Gallons	Gallons	Rs. A. P.	Rs. A. P.
446	318.47	0.71	18.5	0.04	22.34	0.05	574 10 4	1 4 7

Fowlers' Steam Ploughing Tackle worked during the year for 96 days. The details of work and working expenses are given in the following statement :—

The cost and output of working the Fowlers' Steam Ploughing tackle during 1928-29.

Costs				Ploughing			Grubbing			Disc Harrowing			Rolling			Number of working days
Labour	Fuel	Oil	Renewals	Total	Total work	Work per day	Cost per acre	Total work	Acres	Work per day	Cost per acre	Total work	Acres	Work per day	Cost per acre	
Rs.	Rs.	Rs.	Rs.	Rs.	Acres	Acres	Rs.	Acres	Acres	Acres	Rs.	Acres	Acres	Acres	Rs.	
1,425	1,370	228	1,816	4,839	339.5	8.57	5.9	608.5	20.24	2.5	19.57	508	14.9	29.5	..	95.6
*1,383	1,388	226	2,218	5,210	442	9	5.5	209	21.8	2.4	3.5	580	14.9	29.5	1.8	100

*(1,383) : Figures of 1927-28 compared.

A Ransomes Vicker's 23-40 H.P. tractor was purchased during the year. This model is fitted with a belt drive to pump and fan, the fan being balanced by a jockey pulley. Much trouble was experienced by belt breakage and subsequent overheating, and the makers have finally discarded the pump and fitted a thermo-syphon system. As this tractor is in the field against the International, it is regrettable that a thorough testing to find out such defects was not given before shipment. Details of working costs are being kept.

The Consul Thresher threshed wheat and oats doing ten maunds wheat per hour from a crop of Pusa 4. The straw chopping work was quite good.

The representatives of the leading firms in Calcutta attended a meeting held at Pusa on the 2nd April, 1929, to consider the problem of threshing machines for the wheat tract. Among those present were :—

Mr. Lingel, of Messrs. Martin & Co., Calcutta.

Mr. Girling, of Messrs. Martin & Co., Calcutta.

Mr. Dalgarno, of Messrs. Marshall & Co., Calcutta.

Mr. Lawson, of Messrs. Marshall & Co., Calcutta.

Mr. Sitwell, of Messrs. Jessop & Co., Calcutta.

Four Threshing Machines, Marshalls' 4 ft. 6 inch, Ransome's Consul, 20-28 Case, and a small iron portable Thresher of the Bon Accord Company were worked simultaneously, and the threshing problem in India was fully discussed.

IX. PEDIGREE DAIRY HERD.

The strength of the dairy herd at the end of the year under report stood at 359 head. The green fodder supply throughout the year being ample, the condition of the cattle was very good.

Pure Sahiwal herd. The standard for qualification is a lactation of over 4,000 lb. in ten months. The following were the 6 best cows in the herd completing a lactation in the year under report :—

Pure Sahiwal cows.

Serial No.	Name and No. of cow	Date of birth	No. of calving	Quantity of milk given	
				lb.	days
1	Kamli 312 . . .	7-11-16	7	6,590	304
			8	5,620	305
2	Milapi 263 . . .	11-11-14	7	6,395	306
3	Mirja 396 . . .	27-12-19	5	5,988	304
4	Basmati 452 . . .	3-8-22	3	5,939	305
5	Nasoorti 427 . . .	8-3-21	4	5,889	304
6	Mania 388 . . .	4-7-19	5	5,863	306

Montgomery cow Kamli 312, which calved in September 1927 completed her seventh lactation in July, 1928 with 6,590 lb. milk. She calved again in August 1928 and completed her eighth lactation in June 1929 with 5,620 lb. of milk, virtually averaging 20 lb. of milk per day for 20 months.

Cross-bred herd. Work on the cross-bred herd originally started by putting pedigree Ayrshire bulls over rejected Montgomery cows was continued during the year.

The lactations of the only two half-bred Holstein-Montgomery cows in this herd are worthy of note.

Half-bred Ayrshire-Montgomery cows.

Serial No.	Name and No. of cow	Date of birth	No. of calving	Quantity of milk given	
				lb.	days
1	Lena 81 . . .	2-11-20	4	9,237	306
2	Laura 98 . . .	9-8-21	4	8,714	304
3	Nelly 13 . . .	27-10-16	9	8,308	304
4	Glory 22 . . .	14-2-17	7	8,289	304
5	Lilly 103 . . .	10-9-21	4	8,203	306
6	Nora 42 . . .	8-9-18	7	7,824	305

Half-bred Holstein-Montgomery cows.

Serial No.	Name and No. of cow	Date of birth	No. of calving	Quantity of milk given	
				lb.	days
1	Phyllis 131 . . .	10-12-22	3	10,359	305
2	Pearl 130 . . .	4-12-22	3	9,735	305

Among the miscellaneous cross cows, the lactations of Cissy and Rhoda are worthy of note. A photograph of Cissy is given with this, showing the excellent milking shape of this cow and her vastly improved udder resulting from the $\frac{1}{4}$ -Ayrshire cross, while the Montgomery tendency to bottle teats and loose skin is greatly lessened. If cattle of this type can show decent resistance to disease and prove themselves good doers, much may be expected in the future from this cross.

Serial No.	Name and No. of cow	Date of birth	No. of calving	Quantity of milk given	
				lb.	days
1	Cissy 167 . . .	17-1-25	1	6,536	305
2	Rhoda 128 . . .	14-10-22	3	6,382	305



HALF-BRED AYRSHIRE-MONTGOMERY COW TOMINA NO. 123.



HALF-BRED HOLSTEIN-MONTGOMERY COW PEARL NO. 130.



THREE-QUARTER-BRED MONTGOMERY-AYRSHIRE COW CISSY NO. 167.

Statement of milk yield in lb. for 1928-29.

Month	MILK YIELD OF				Total yield of crossbred and Montgomery cows	AVERAGE YIELD PER DAY AND PER COW PER DAY								
	CROSSBRED COWS					CROSSBRED COWS			MONTGOMERY COWS		TOTAL OF CROSSBRED AND MONTGOMERY COWS			
	$\frac{1}{4}$ -Ayrshire cows	Miscellaneous cows	Total of crossbred cows	Pure Montgomery cows		$\frac{1}{4}$ -Ayrshire cows	Miscellaneous cows		Total of crossbred cows	MONTGOMERY COWS		TOTAL OF CROSSBRED AND MONTGOMERY COWS		
							Average per cow per day	Average per cow per day		Average per cow per day	Average per cow per day	Average per cow per day	Average per cow per day	
July 1928	15,625	9,031	24,656	38,177	504	20.2	291	18.2	795	19.4	436	16.1	1,231	18.1
August "	16,624	7,279	23,903	36,943	536	20.6	235	14.7	771	18.3	421	15.0	1,192	17.0
September "	15,950	6,261	22,211	35,591	532	19.7	208	13.0	740	17.2	446	13.9	1,186	15.8
October "	17,395	6,510	23,905	37,744	561	20.0	210	15.0	771	18.4	446	14.9	1,217	16.9
November "	15,547	6,043	21,590	33,903	518	21.6	202	14.4	720	18.9	410	14.1	1,130	16.9
December "	19,410	8,396	27,806	39,420	626	23.2	271	15.1	897	19.9	375	13.9	1,272	17.7
January 1929	22,748	8,532	31,280	42,753	734	24.5	275	16.2	1,009	21.5	370	12.8	1,379	18.1
February "	22,005	8,085	30,090	39,865	786	25.4	289	18.1	1,075	22.9	349	13.4	1,424	19.5
March "	23,905	8,449	32,354	42,984	771	24.1	273	18.2	1,044	22.2	343	14.3	1,387	19.5
April "	20,026	7,230	27,256	37,604	667	21.5	241	17.2	908	20.2	345	15.0	1,253	18.4
May "	18,922	7,032	25,954	37,814	610	21.0	227	17.5	837	19.9	383	14.2	1,220	17.7
June "	15,214	6,160	21,374	35,115	507	19.5	205	15.8	712	18.3	458	13.9	1,170	16.2
TOTAL	223,371	89,008	312,379	457,913	..	..	..	..	..	..	..	..	..	..
Average per month 1928-29.	18,614	7,417	26,031	38,159	613	21.8	244	16.1	857	19.7	398	14.3	1,255	17.6
Average per month 1927-28.	16,585	6,827	23,412	37,632	544	21.6	224	17.6	708	20.3	466	12.7	1,234	16.5

Percentage of cows in milk. Throughout the year the percentage of cross-bred cows in milk was 69 compared with 68 per cent of the preceding year the maximum being 77 in March and the minimum 56 in November.

In the Montgomery herd the average was 51 per cent. with a maximum of 58 per cent. in January and a minimum of 45 per cent. in April.

Calf rearing. The mortality among pail-fed calves reared in 1928-29 was 7.3 as against 9 per cent. in the previous year.

Clean milk. According to the standard adopted by the Ministry of Health in Great Britain, certified milk which is the highest grade must not contain more than 30,000 bacilli per c. c.

The bacteriological test of the milk was conducted independently by the Imperial Agricultural Bacteriologist and as a result of careful handling of the cows and the milk, the plate count per c. c. was appreciably lower than the English standard during the year 1928, the average bacterial content being 13,337 per c. c. The highest and the lowest figures were 22,200 and 3,800 respectively.

Over $4\frac{1}{2}$ lakhs lb. of milk was produced during the year—a slight increase on last year's production. The average yield of the cross-bred cows dropped to 19.7 as against 20.3 in the previous year. This, however, is due to the inclusion of more and more miscellaneous crosses in the half-bred herd and the continuity of experiments reducing the English blood to $\frac{1}{4}$ is bound to tell on the milk yield, as the leading $\frac{1}{4}$ -Ayrshire - $\frac{3}{4}$ -Sahiwal gives only 6,000 as against 12,000 by the leading half-bred.

The average yield of the Montgomery herd went up to 14.3 lb. from 12.7 lb. of the previous year.

Sales. Fifty-six animals came under the hammer in 1928-29 and the prices realized are shown against those of the previous year.

Number of cattle sold during 1928-29.

No. of cattle	Description of cattle	Price obtained	Average price per animal 1928-29			Average price per animal 1927-28		
		Rs.	Rs.	A.	P.	Rs.	A.	P.
16	Montgomery cows . .	3,560	222	8	0	98	11	8
13	Cross-bred cows . . .	2,090	160	12	0	215	2	0
5	Montgomery heifers . .	992	198	6	0	30	0	0
3	Cross-bred heifers . .	625	208	5	4	27	0	0
11	Montgomery bulls and young bulls.	2,580	234	8	8	166	1	0
8	Cross-bred steerling . .	420	52	8	0	....	
56		10,267						

The steady rise in the price fetched by the Sahiwal stock is a testimony to the standard which the herd has now reached.

Financial results. The following are the cash sales for the present year and the two previous years :—

Year	Farm produce	Milk and milk produce	Sale of cattle	Total
	Rs.	Rs.	Rs.	Rs.
1928-29	14,553	31,118	10,398	56,069
1927-28	9,875	26,516	9,311	45,702
1926-27	9,272	£ 26,602	8,303	44,171

X. PROGRAMME OF WORK FOR 1929-30.

1. (a) Practical treatment of a pedigree dairy herd of Indian cattle and a pedigree dairy herd of Montgomery-Ayrshire cattle.

(b) Continuance of experiments with regard to fixing a type of Montgomery-Ayrshire most suitable to Indian conditions.

2. Practical treatment of a 1,200-acre mixed farm with particular attention to profitable modern machinery and the financial results of the work.

The bulk of the produce of the Pusa Farm is used for the maintenance of the dairy herd. The rotation adopted aims at the upkeep of the fertility of the land along with supply of concentrated food and long fodder and a constant supply of green fodder throughout the year. Included in the above is the study on a practical scale of :—

- (a) Rotations.
- (b) Crops for fodder, seed and silage.
- (c) Implements and machinery.
- (d) Technique of cultural operations.

3. Continuation of collection of data and results regarding the cost and capabilities of the steam ploughing tackle on estates of this size.

4. Experiments with various types of motor tractors and ploughs for collection of data and working costs and for determination of most suitable types of tractors and implements for India. Also collaboration with manufacturers regarding the manufacturing and introduction of improvements in standard types to suit Indian conditions.

5. Experimental work at Pusa—

(a) Rotational experiments.

(b) Trial of new varieties of crops, especially leguminous fodder crops.

(c) Manurial experiments, especially seasonal and quantitative tests with phosphates.

(d) Trial of sugarcane varieties suitable for growth without irrigation, along with the S. B.

6. Demonstrations, exhibitions and sales of surplus dairy stock, etc., will be held from time to time as occasion offers.

7. *Touring and advisory.* Visits will be paid to provincial agricultural centres.

REPORT OF THE IMPERIAL DAIRY EXPERT.

(WILLIAM SMITH)

I. INTRODUCTION.

Mr. Zal R. Kothavala, B.Ag., B.Sc., N.D.D., held charge of the office of the Imperial Dairy Expert from 1st July to 14th October, 1928. I took over charge from Mr. Kothavala on the 15th October, 1928, on my return from leave.

The ever increasing interest taken by the public and the various departments of agriculture in India in cattle breeding and dairying questions continued throughout the year, and the tremendous economic importance of this problem is gradually being realized in the country. Early in the year the Report of the Royal Commission on Agriculture in India was published, and the interest which this report created and the notice which was taken of its recommendations, especially those relating to cattle breeding and milk production, by all sections of the Indian press, is a proof of the ever growing interest of educated India in these questions; and consequently the demands on this office for information and guidance in these matters from all over the country were greater during the year under review than ever before. As in the previous year, the demand for bulls of dual purpose efficiency for stud purposes bred at the Karnal farm was greater than the supply available. The live stock officers of practically all the Agricultural Departments in the country are endeavouring to issue stud bulls of the right draught type for their particular conditions and which also have the capacity for sireing milk yielding cows. The decision of the Mysore Government made during the year to domesticate their enormous Amrit Mahal herds and in future breed for milk as well as draught qualities is significant of the trend of expert opinion in this direction. The Mysore Government have realized that they cannot afford to breed cattle any longer on the one purpose basis. The cows must be milkers as well as producers of draught bullocks. The extension of the activities of the Bengal Co-operative Department in following up their signal success on the organization of the Calcutta milk supply, by the establishment of Co-operative Milk Unions at Darjeeling, Dacca and Chittagong, and the erection and equipment of a modern milk factory in Darjeeling to plans and specifications furnished by this office, is a pleasing feature of the year's progress. No less so is the remarkable progress made in the development of the city milk supply of Madras by the union of milk producing co-operative societies organized by the Co-operative Department of that presidency. This Section has

supplied plans and machinery specifications for a model milk factory on a large scale to this new and progressive union, and it is understood that arrangements are in progress to erect this new plant in the near future. As was emphasized in last year's report, the development of the cattle of all the small holding countries of the world has followed and not preceded the organization of the sale of milk and the manufacture and sale of milk products. Not only so, but in practically all the countries of the world where the cultivation is done by peasant proprietors occupying small areas, this development and organization of the sale of milk and manufacture of milk products has been done on co-operative lines. The activities of the Co-operative Department of Bengal and Madras above referred to are the more significant and might well be copied by the Co-operative Departments of all the Governments in this country. In order to keep pace with these lines of progress, investigation and research into the treatment of village milk for long distance transport, the manufacture of dried milk, condensed milk, casein and milk products generally is urgently needed. As pointed out in previous reports, it is futile to expect the Indian cultivator to take active steps to improve the quality of his cattle when circumstances force him to sell *ghi* at half its world value and throw away the butter milk with its valuable casein contents. Dairying is the ideal village industry for India and its development offers the only solution of the problem of village unemployment, as all classes and castes are prepared to handle the cow and her products.

The reports of the Superintendents of the Bangalore, Karnal and Wellington farms and the Anand Creamery speak for themselves. The Karnal herd has now reached a total of 623 of all ages and is being gradually increased by breeding and purchase to the maximum of 1,000 aimed at. The policy of this farm—in fact its “raison d'être”—is the production of the dual purpose cow, profitable as a milk yielder and at the same time the producer of an efficient and suitable field bullock. Two types or breeds of Indian cattle are used—the Haryana suitable for larger areas of heavy soil where powerful working cattle are required, and the Thar-Parker, a lighter and smaller type suitable for smaller cultivators and light soils. So far the results achieved are encouraging. The heavier milking cows are producing what are undoubtedly the best draught type of bulls in both breeds. In fact, so encouraging are the results at Karnal in demonstrating the practicability of the dual purpose idea, that the establishment of a herd of the famous Bhagnari breed of cattle of Baluchistan is contemplated for their development on dual purpose lines and for the preservation of this famous breed in the shape of a pedigree herd.

The deplorable outbreak of disease referred to in the report of the Superintendent of the Wellington farm has cost the farm dearly, but all animals on this farm have been inoculated by the serum simultaneous

method as a prevention against future attacks of rinderpest and steps have been taken to renew these inoculations regularly as the young stock come to suitable age.

The Anand Creamery at the commencement of the year had 11,973 lb. of butter in cold store. On two previous occasions a stock of butter had been accumulated in what was looked upon as the plentiful season when milk was cheap. In both these previous instances the butter was sold at profitable prices during the scarce season in the hot weather. This year, however, there was no scarcity of milk in Gujarat at any period of the year, and the cold stored butter had to be sold at a considerable reduction in price. No accumulation of butter in cold storage will be made in future at the Anand Creamery. In order to deal adequately with the separated milk at the Creamery in the monsoon and to carry out research work in connection with the manufacture of dried milk, a milk drying plant is urgently required at Anand and a tin making plant for the manufacture and closing of butter tins is needed.

During the year under review no less than 120 animals belonging to the Bangalore farm were used for feeding experiment of one kind or another conducted by the Physiological Chemist to Government. These experiments entail the close confinement of the cattle used and although the feed given is generally sufficient to sustain the animals, it is not normal commercial feeding and the yields of the Bangalore herd and the frequency of calving are adversely affected by these feed trials. It is recognized that these experiments are necessary and of great value to the cattle industry of India, but the fact that the Bangalore herd is almost continuously used for this class of work should be kept in view when the yields of the animals are being compared with those of cattle kept under normal conditions.

A cinematograph film 2,200 feet long was prepared during the year illustrative of the work of the Bangalore farm and depicting Indian dairying as practised at Bangalore.

Central Bureau of Animal Husbandry. As stated in my report for 1927-28, the question of the development of the Central Cattle Bureau has been to some extent held in abeyance pending action on the recommendations of the Royal Commission on Agriculture, but throughout the year the bureau has endeavoured to keep buyers and sellers of the highest class of pure breeding stock in touch with each other and to encourage the formation of herds of pure types of cattle by private owners as far as possible.

II. TRAINING.

The fourth group of students studying for the Indian Dairy Diploma at the Allahabad Agricultural Institute finished their term in December 1928 and six of these sat for examination; of whom three passed. In

addition, four students who had failed last year were allowed to reappear for the examination after a repeat course of six months at the Imperial Institute of Animal Husbandry and Dairying, Bangalore ; and three of them passed.

Four students for varying periods of training from Assam, Bihar and Orissa and Kapurthala State and 12 Dairy Diploma students of the Allahabad Agricultural Institute received technical instruction during the year at the Bangalore and Karnal Farms and the Government Creamery at Anand. In addition, one Cattle Farm Superintendent deputed by the U. P. Government and four European soldiers of the Bangalore Brigade joined for vocational training in dairying and cattle-breeding at the Bangalore Dairy Institute on 1st April 1929.

Five post-graduate students and one post-diploma student completed their course of training at the Farms and the Creamery under my charge during the year, and three post-graduate students joined for training in January 1929. The research scholar from the Punjab who joined the Bangalore Institute in October 1927 for a two years' course continues his research work at the farm here.

Mr. F. J. Warth, Physiological Chemist, and his staff continued their assistance in the training of the students and the examination of feeding stuffs for all the farms. I acknowledge the ready help and valuable advice so freely given by Mr. Warth at all times.

III. WORK DONE FOR LOCAL GOVERNMENTS, INDIAN STATES, MUNICIPALITIES AND ADVICE GIVEN TO THE GENERAL PUBLIC IN INDIA, ALSO TO PERSONS OR GOVERNMENTS OUTSIDE INDIA.

Bombay. At the request of the Livestock Expert, Bombay Presidency, this Section took part in the Bombay Agricultural Show held at Ahmedabad in November 1928 ; in that dairy products manufactured at the farms and the creamery under my charge were exhibited, and a number of Thar-Parkar cattle of the Imperial Cattle Breeding Farm, Karnal, were sent to this Show for demonstration. Demonstrations were given in the manufacture of butter and the handling of pasteurised milk, the students of the Imperial Institute of Animal Husbandry and Dairying, Bangalore, taking part in the Show. The writer acted as a judge of cattle, dairy produce and dairy machinery at the Show and my assistant Mr. Kothavala adjudicated in the butter making competitions.

At the request of the Agricultural Organiser, Co-operative Societies, North Division, Surat, Mr. Kothavala visited Surat in July 1928, and as a result of this visit made detailed recommendations for further developing the Milk Society with the object of supplying clean milk to the city. Mr. Kothavala again visited Surat in October 1928 at the request of the Chairman, District Co-operative Board, Surat, in order

to deliver a public lecture illustrated with cinema films on "City milk supply and its improvements." This lecture was largely attended by the public and was presided over by the Collector of Surat.

The Acting Professor of Agricultural Engineering, Poona, was supplied with copies of blue prints of standard plans of dairy buildings with a note on estimated cost.

The Divisional Inspector of Cattle Breeding, Central Division, Pandharpur, was supplied with a note on the number of dairy cattle in India and abroad during the last ten years together with a statement showing their average milk yield, analysis of milk and butter milk and composition of butter.

The Deputy Superintendent, Civil Veterinary Department, Poona, was supplied with information regarding Gir bulls available for sale at the Palace Dairy, Baroda. The Manager, Sorwajanika Jivadaya Khata, Ghatkopar, was supplied with a copy of the list of bulls available for sale at the Imperial Institute of Animal Husbandry and Dairying, Bangalore. The Editor and Manager, "Gorakshan," Poona, was supplied with a note on the research work being done at the three farms and the creamery under my charge.

Mr. Kothavala, while in Karachi in August 1928, visited the several cattle stables of the Karachi Pinjrapole and advised them on the spot as to what further improvements they could make in their organization in order to produce milk on modern lines.

The Engineer, Town Planning, Shikarpur, was advised as to the best way of reorganizing the local Pinjrapoles on modern lines.

Mr. J. A. Fahey, retired Stable Superintendent to H. H. the Gaekwar of Baroda, visited Bangalore in November 1928 and discussed with the writer the advisability of establishing a dairy farm on his lands at Talegaon for supply of milk to Poona and Lonavla, and at his request Mr. Kothavala visited his lands at Talegaon in December 1928 in order to advise him as to their suitability for establishing the proposed dairy farm.

Messrs. Mulji Surji & Co., Bombay, were advised regarding the establishment of a *Ghi* factory, and in December 1928 I visited Bombay in order to discuss with the directors of this company details of a scheme for the establishment of a *Ghi* factory in Junagadh, and they were supplied with all possible information.

The Manager of the Sri Govardhan Sanstha and Gorakshan Karyalaya, Poona city, was supplied with a plan for housing dairy cattle at Wai.

Kathiawar. H. H. the Maharaja of Dhrangadhra was supplied with a copy of my note on the improvement of cattle in the Jaipur State for guidance in effecting improvements in the cattle of his State.

In addition to the foregoing, specific advice and information on dairying and cattle breeding matters were supplied to firms, public bodies

and individuals at Bombay, Byculla, Belgaum, Baroda, Bagalkot (Bijapore), Sabarmati (Ahmedabad) and Karachi.

Bengal. The Livestock Expert, Bengal, Dacca, was given the loan of dairy films of this Section for demonstration work and he was supplied with 16 stud bulls from the Imperial Cattle Breeding Farm, Karnal. The Deputy Director of Agriculture, North ern Circle, Bengal, was supplied with copies of ration statements of our Karnal and Bangalore Farms.

The Principal, Veterinary College, Calcutta, was advised as to the best type of stud bulls and the number of such bulls available for sale at the Karnal and Bangalore farms and with Mr. J. R. Patel of Karachi.

At the request of the Superintendent, Calcutta Co-operative Milk Societies Union, I visited Calcutta in January 1929 in order to confer with him regarding various proposed extensions of activities in the direction of co-operative dairying. This officer was given the loan of a number of dairy films of this Section for propaganda work, and he was advised from time to time during the year under report on dairying matters. Two young bulls were also supplied to this Milk Union from our Karnal farm.

At the request of the Co-operative Department, Bengal, I proceeded to Darjeeling and gave advice concerning the new creamery buildings in course of construction, and also advised the officers of the Co-operative Department regarding the disposal of village milk produced in the Darjeeling District and later on submitted them a detailed note. On my return from Darjeeling, I visited the zemindari of Sir Daniel Hamilton at Gosaba and as a result of this visit I provided him with a note on the improvement of the cattle of his zemindari. At the request of Mr. G. D. Birla, M.L.A., I visited certain lands near Pancharapara and advised him regarding the suitability of these lands for the establishment of a dairy farm. Later on I supplied him with a complete scheme with dairy plans and machinery specifications for his proposed dairy farm. He was also advised as to the best time for purchasing his foundation stock.

While I was at Calcutta, Mr. Narayan Das Barjoria discussed with me matters connected with dairying and cattle breeding, and at his request I supplied him with copies of photographs depicting the interest taken by Mr. M. K. Gandhi in several visits to the Imperial Institute of Animal Husbandry and Dairying, Bangalore, during his sojourn at Bangalore. From Calcutta I also visited Dr. Sen's lands near Bandel with a view to advise him as to its suitability for establishing a dairy farm.

The St. Andrews Homes, Kalimpong, were supplied with a plan for a small dairy farm together with a specification of dairy plant and a note of estimated cost of dairy buildings.

In February 1929 I visited Bhiwani and Karnal in order to select dairy cattle for Co-operative Dairy Societies in Bengal and for Sir Daniel Hamilton.

In addition to the foregoing, specific advice and information on dairying and cattle breeding matters were supplied to firms, public bodies and individuals at Makalpur (Hooghly), Calcutta, and Saidabad (Murshidabad).

Madras. The Deputy Director of Agriculture, Livestock, Madras, was in correspondence with this office throughout the year on dairying and cattle breeding matters and he was supplied with information from time to time. He was also supplied with a plan for a milking shed and a milk recording room for the Leper Settlement, Chingleput. Towards the end of March, 1929, at the request of Mr. Littlewood, I visited Madura and inspected a number of sites for the establishment of a municipal dairy farm at that station, and later on, in co-operation with this officer, I submitted a complete scheme with dairy plans and machinery specification, etc., for the establishment of a municipal dairy farm at Madura.

At the end of April 1929, the Registrar, Co-operative Societies, Madras, visited the Bangalore Dairy Institute and conferred with the writer regarding the advisability of establishing a Central Milk Factory at Madras for the Co-operative Milk Societies Union, and as a result of this conference I submitted a complete scheme with dairy plans and machinery specifications, etc., for the establishment of such a concern.

At the request of the Director of Agriculture, Madras, the Bangalore Dairy Institute took part in the Madras National Health and Baby Week held at Madras in January 1929, in that dairy products of this Section were exhibited and the production of clean milk and butter making, etc., were demonstrated.

The Madras Milk Supply Union Ltd., were advised regarding the treatment of milk before sale to the public in order to prevent its getting sour as a result of long storage before issue. Later on they were supplied with a note on the cost of installing a modern pasteurising and cold storage plant and other dairy machinery.

At the request of the Chairman, Ootacamund Municipality, his revenue officer was afforded facilities to study the system of accounts in vogue at the Imperial Institute of Animal Husbandry and Dairying, Bangalore.

Mr. A. V. Bashyam Reddi of Cuddalore was in correspondence with this office throughout the year on dairying and cattle breeding matters and he was supplied with information from time to time. He was also supplied with a note on the cost of producing milk with 40 cows and 40 buffaloes together with lists of establishment and dairy utensils.

Bangalore Civil and Military Station. At the request of Mr. H. Saliah Mohamed Sait, Mr. Kothavala visited his lands near Bangalore in order

to advise him regarding its suitability for a dairy farm and he was furnished with a complete scheme for the establishment of a dairy farm on his lands.

The Veterinary Superintendent, Tasker Veterinary Hospital, was supplied with a plan of a stable for housing stud bulls. He was also advised as to the best type of stud bull he should keep for mating cows of the local gowallas and the general public, and arrangements have been made to obtain for him an Ayrshire bull from the St. Andrews Homes, Kalimpong.

On 21st June 1929, I delivered a public lecture under the auspices of the Bangalore Humanistic League on the economic effect of cattle breeding to India. This lecture was presided over by Dr. Leslie C. Coleman, Director of Agriculture in Mysore, and there was a large attendance.

Coorg. At the request of Mr. Shambhavananda of Ponempet, Mr. Rangasamy, Senior Supervisor, Bangalore Dairy Institute, delivered a public lecture in Kanarese at Mercara and two at Virarajendrapett on dairying and cattle breeding. These lectures, which were illustrated with films and lantern slides, were attended by the delegates to the Coorg Provincial Conference.

Mysore State. The Director of Agriculture was advised regarding the control and treatment of mange amongst the cattle at the Rayankere cattle farm and at his request, the dairy products of the farms and the creamery under my charge were exhibited at the Dairy Exhibition held at Mysore during the Dasara festival. I also examined their agricultural students in dairying and cattle breeding in April 1929. A complete scheme for the establishment of a central cattle breeding farm for the Amrit Mahal Department with building plans was supplied to the Director of Agriculture at his request.

At the request of the Director of Public Instruction, Mysore, an artist of the Medical College, Bangalore, was permitted to photograph the process of milk production and other activities of the Bangalore Farm in order to manufacture lantern slides of dairy farming and clean milk production.

In addition to the foregoing, specific advice and information on dairying and cattle breeding matters were supplied to firms, public bodies and individuals at Mysore, Kolar Gold Fields, Alur-Ron, Madras, Karapa (Cocanada), Elloppatti, Kodaikanal, Kurnool, Ellore and Katupur.

Punjab. The Livestock Expert, Punjab, was supplied with copies of standard plans of dairy buildings. The Director of the Civil Veterinary Department was given the loan of a cinema film illustrative of H. E. the Viceroy's visit to the Karnal Farm and of a number of lantern

slides dealing with cattle breeding in India for use on the demonstration train run by the Government of the Punjab.

Mr. A. C. Aggarwala, Professor, Veterinary College, Punjab, Lahore, was supplied with copies of a number of publications on dairying and cattle breeding. He was also provided with facilities to study the routine work of the farm of the Dairy Institute, Bangalore.

At the request of Dr. Ramji Narain, Assistant Agricultural Chemist to the Government of Punjab, arrangements have been made at the Bangalore Institute to test the suitability of the vegetable rennet, prepared by him, in the manufacture of cheddar cheese.

Sardar Dost Mohamed Khan, proprietor of cattle farm at Jahangirabad (Multan), was advised on cattle breeding matters. Mr. Munshi Ram of Balasmand (Hissar) was advised as to the best type of cows and buffaloes for a dairy farm, he was also advised as to the best type of milking machines, butter churns, etc. S. Harnam Singh Gill of Majitha (Amritsar) was advised as to the best fodder crops for dairy cattle and he was supplied with a detailed note regarding the cultivation of Rhodes and Guinea grasses in India. Messrs. Hakim Singh and Sons, Amritsar, were advised regarding butter making and the manufacture of casein and their disposal.

In addition to the foregoing, specific advice and information on dairying and cattle breeding matters were supplied to firms, public bodies and individuals at Lahore, Dalowali (Sialkot) and Wah.

Delhi. At the request of Mr. P. P. Gupta, I.D.D., Mr. Kothavala visited his dairy farm near Delhi in July 1928 and advised him on the spot as to what improvements he could make in the management of his farm. The Health Officer, Delhi Municipality, is in correspondence with this office regarding the improvement of the milk supply of Delhi and I have promised to discuss with him this matter at Delhi when next I go on tour to the Punjab.

Jind State. The Settlement and Land Revenue Officer, Sangrur, was supplied with particulars of stud bulls available for sale at the Karnal farm and the Lyallpur Agricultural College Dairy.

Nabha State. At the request of the Administrator, Nabha, a list of dairy cattle available for sale at the Nabha State Dairy was circulated to prospective buyers.

Patiala State. The Nazim Sardar Lassikhana Mubarik, Patiala, was furnished with particulars of pure English bulls available for sale with the Colonial Homes, Kalimpong, and the Agricultural Institute, A. P. Mission, Allahabad.

United Provinces. The Principal, Agricultural Institute, A. P. Mission, Allahabad, was advised as to the suitability of Mr. Hansen as a professor in dairying for their Institute, he was also advised on cattle breeding, and was supplied with particulars of publications on cattle

breeding. The Officer in charge of dairy of this institution was supplied with information relating to the nutritive value of *ghi* and butter.

The Dalhousie Dairy Farm, Naini Tal, were supplied with information as to where they could obtain a proper type of pasteurising plant, they were also supplied with particulars of books for reference on pasteurisation of milk. Messrs. Baya & Co., Mussoorie, were advised as to how they could improve the hill cattle for milk production. Rao Bahadur Madan Mohan Sinha of Cawnpore was advised as to the best fodder crops he could grow on his lands for his cattle. The Deputy Director of Agriculture in charge of cattle breeding, U. P., was given the loan of cinema films on dairying and cattle breeding. The Deputy Director of Agriculture, Jealikote (Naini Tal), was furnished with particulars of lantern slides possessed by this Section and was also informed of the price at which he could get a set of these lantern slides made for himself. The Civil Surgeon, Garhwal, was advised as to the best type of cattle for his district and the source of supply of such cattle.

In addition to the foregoing, specific advice and information on dairying and cattle breeding were supplied to private individuals at Allahabad, Meerut and Karanpur (Dehra Dun).

Central Provinces. The Deputy Director of Agriculture in charge of cattle breeding, Central Provinces, visited the Imperial Cattle Breeding Farm, Karnal, in January 1929, and selected 8 Haryana bulls for his province, and at his request I accompanied him to Rohtak to assist him in the selection of more Haryana cattle for his department. The Principal, Agricultural College, Nagpur, was supplied with information on feeding of bonemeal and other phosphates to calves, and he was furnished with a descriptive list of publications on feeding of minerals to cattle. The Extra Assistant Director in charge of animal husbandry, Central Provinces, was advised regarding manufacture of casein in order to utilize his surplus separated milk. This officer was put in touch with firms dealing in condensed milk machinery and milk powder plant.

The Director of Institute of Plant Industry, Indore, was supplied with particulars of the "Burdizzo" bloodless castrating instrument for castrating male calves not required for stud purposes.

Rajputana. The Superintendent, Agricultural Model Farm, Srinagar (Rajputana), was advised as to the best breed of buffaloes suitable for the district of Ajmer-Marwar; he was also supplied with the names of firms dealing in dairy machinery in India.

S. Kartar Singh, Registrar, Co-operative Societies, Ajmer, interviewed the writer at Calcutta in January 1929 and was advised as to the improvements which could be made in the cattle of his district.

Bihar and Orissa. The Director of Agriculture, Bihar and Orissa, was supplied with particulars of two Thar-parkar bulls available for

sale at the Karnal farm, and he was advised as to the suitability of a candidate possessing the Indian Dairy Diploma of the Bangalore Dairy Institute for the post of a Livestock Inspector; he was also advised regarding the grant of a foreign scholarship to a student at present undergoing training for the Indian Dairy Diploma course. The Deputy Director of Agriculture, Chota-Nagpur Range, was supplied with particulars of dairy machinery suitable for converting a small quantity of surplus milk into butter; he was also advised as to the best type of cows for his district and the best means of transporting cattle from Sind to Kanke. This officer was also supplied with particulars of breeds of pigs for the establishment of a piggery at the European Mental Hospital, Kanke. The Deputy Director of Agriculture, North Bihar Range, was advised as to the best way of transporting cream for butter-making over long distances and the price obtainable for such cream in Calcutta. The Assistant Director of Agriculture, Livestock, Monghyr, was advised regarding weaning, rearing and feeding of calves from birth. The Director of Civil Veterinary Department, Patna, was advised as to the class of engineer he should engage for looking after the dairy machinery installed at the dairy farm attached to the Veterinary College, Patna.

At the request of the Superintendent, Sewage and Dairy Farm, Tata Steel and Iron Co., Ltd., Jamshedpur, I visited Jamshedpur in January 1929 to confer with the authorities there regarding further developments in their dairying and cattle breeding activities. While there, I delivered a public lecture illustrated with films on the importance of milk supply which was attended by the Town Administrator and the principal residents of the Station. Later on I supplied the Welfare Officer of the company with a detailed note on the milk supply of Jamshedpur from the consumers' point of view, the milch cattle of the town and the consequent raising of the general standard of living of the cow owners.

The Saran Engineering Co., Ltd., Muzaffarpur, were put in touch with the dealers in dairy machinery in India. The Manager of the Bettiah Estate was supplied with information regarding the tabular cow stanchions manufactured in India and Mr. Sib Prasad of Kanitaul (Darbhanga) was supplied with a detailed note explaining the process of manufacture of casein.

Assam. The Director of Agriculture, Assam, was supplied with particulars of Scindi bulls available for sale at the State Dairy, Nabha, and the Deputy Director of Agriculture, Jorhat, was furnished with particulars of Thar-parkar bulls available for sale at the Karnal farm. The latter was also supplied with copies of ration statements of the Karnal and Bangalore farms in order to guide him in the feeding of calves.

I visited Shillong in January 1929 to assist the newly appointed Livestock and Dairy Expert in drawing up the policy of cattle breeding for Assam, and while at Shillong I had an interview with the Governor of that province. Later on, at the request of the Director of Agriculture, I selected at Bhiwani a number of stud cattle. In February 1929 I visited Karachi to select, brand and ship to Assam stud Scindi cattle on behalf of the Livestock and Dairy Expert, Assam. The Livestock Expert was also advised on cattle breeding matters from time to time, and he was supplied with sample forms of cattle record books in use on our farms for reference. He was also given the loan of dairy posters for exhibition during the Baby Week.

Mr. B. C. Roy of Barpalhar (Assam) was furnished with helpful information regarding the establishment of a piggery. Mr. J. E. Dawson of Hatekera was supplied with information regarding the source of supply of Scindi cattle.

Burma. The Director of Agriculture, Burma, was advised regarding the transport of milk over long distances. The Professor of Agriculture, Mandalay, was supplied with a note on cost of importing Scindi cows from Karachi and he was also supplied with information about a dairy plant suitable for small dairies.

Mr. J. R. Andrews of Rangoon was advised as to the best class of dairy cattle suitable for Rangoon and he was also supplied with a list of establishment necessary for running a dairy farm of 50 cows. Mr. P. J. Toole of Rangoon was furnished with information regarding homogenizing of milk and the treatment of milk transported over long distances.

Port Blair. At the request of the Executive Commissariat Officer, Port Blair, I selected, branded and shipped for him 12 Scindi cows and one Scindi bull. Later on I advised him as to the best type of stud bull suitable for mating local cows in the Andamans.

Advice given to foreigners. The Chief Agricultural Research Officer, Rustam (Iraq) was supplied with particulars and prices of stud bulls of Indian breeds and of Ayrshire bulls available for sale in India. The President de la Chambre d' Agriculture, Pondicherry, was furnished with a copy of the publication issued by this Section on Murrah buffaloes, and he was advised to purchase buffaloes of this type from Hyderabad (Sind). The Director of Agriculture, Ceylon, was furnished with a list of bulls available at the Karnal farm, and he was also informed that there is a demand for Annatto in India for butter colouring. Messrs. E. J. Brooks & Co., of New York, were supplied with a list of principal butter factories and dairies in India. Mr. K. S. Ishaiyek of Baghdad was advised regarding the purchase of Scindi cows. Mr. J. E. Proctor of Dalewood, Liverpool, was supplied with a list of publications issued by this section on dairying and cattle breeding. Professor Nottbohm

of Hamburg 36 was supplied with a set of photographs illustrative of various breeds of Indian cattle and with information regarding manufacture of condensed milk from cows' milk and buffaloes' milk. The Societe Pour le Developement des Relations, Economiques et Culturelles Avec, L'Orient, Prague, were given the names of firms dealing in cream separators in India.

IV. GENERAL.

The first Instalment of a paper on "City Milk Supply" by Mr. Zal R. Kothavala, as well as an article by Mr. Kothavala and the Post-graduate students of the Bangalore Institute containing the results of an investigation into the variation of fat and solids not fat of cows milk, were submitted to the Agricultural Adviser for publication in "The Journal of the Central Bureau for Animal Husbandry and Dairying in India."

A brief summary of the progress of research in cattle breeding and dairying during 1928-29 was written for inclusion in the annual report of the Committee of the Privy Council for Scientific and Industrial Research, London.

The Manual of Dairy Farming by Mr. B. K. Ghare was reviewed by Mr. Kothavala for the Journal of the Central Bureau for Animal Husbandry and Dairying in India.

KARNAL, BANGALORE AND WELLINGTON FARMS AND ANAND CREAMERY.

Karnal. The farm has 2,154 acres of land, of which 327 acres are under direct cultivation, 1,002 acres are on *batai*, (share system), 242.5 acres are on cash rental, and the balance of 582.5 acres is represented by buildings and roads and grazing areas. Out of 327 acres under direct cultivations 78 acres are green manured and 100 acres are manured with cattle yard manure. Out of the 2,154 acres, 1,365 acres come under canal irrigation. The yields of crops obtained this year are shown in Appendix I of this report. It will be noticed that the yields are considerably higher than those obtained last year in spite of the rainfall being low. Forty-eight acres of land were lent for cultivation of Pusa wheat. The grain harvested was distributed to the U. P. Agricultural Department. Four acres were lent for gram, and the yields were also distributed to the Punjab and U. P. Agricultural Departments.

	Punjab.	U. P.
Gram	5 md. 24 sr.	20 md.
Wheat . . . . .	..	660 ..
Linseed	2 md. 2 sr.	..

The Agricultural Research Institute, Pusa, also experimented with two acres of linseed and the seed is being distributed to the requiring

parties. The land under *batai* and direct cultivation was sown with *juar*, sugarcane, rice, gram and wheat.

2. During the year, the existing model milking shed was extended to accommodate 100 cows. A milk record room and a drain was added to it.

3. The strength of the herd at the commencement of the year was 586 head and at the end was 623. One hundred and eighty-nine births were recorded, of which 51 were born of heifers. Among 79 cattle of all classes dead, 67 were calves under one year. Of the 110 animals sold, 49 were bulls purchased by different Governments for stud purposes. It will be noticed that the mortality among calves under one year is still high and could be greatly reduced if sanitary calf pens are built.

The following table shows the breed and class of cattle maintained at the farm during the year :—

Breed and class of animals	1st April, 1928	31st March, 1929
<i>Cows</i>		
Thar-parkar	89	96
Haryana	63	67
Sahiwal . . . . .	..	1
Half-bred . . . . .	..	2
<i>Cow young stock and calves—females</i>		
Thar-parkar	93	83
Haryana	67	73
Sahiwal	2	2
Half-bred	3	Sahiwal cross 1
<i>Cow young stock and calves—males</i>		
Thar-parkar	91	95
Haryana	55	51
Half-bred	1	..
Sahiwal	5	2
<i>Cow Bulls</i>		
Thar-parkar	5	4
Haryana	1	1
Murra buffaloes	19	24

Breed and class of animals	1st April, 1928	31st March, 1929
<i>Murra young stock female</i>		
Females and calves	22	31
Murra young stock males and calves . . .	12	16
Murra-bulls	2	1
Bullocks	55	72
Horse	1	1
TOTAL .	586	623

The general health and condition of the cattle was fair at the beginning of the year and by July the cattle were in splendid condition, which continued throughout the end of the year. One hundred and fifty-three animals were inoculated against rinderpest by the serum-simultaneous method without any casualty.

Except for a few cases of Johne's disease and one of black quarter, the deaths were due to ordinary natural complaints.

The following table shows the number of deaths among different classes of animals died in the year and the number of animals condemned :—

	ADULT STOCK				YOUNG STOCK				Bullocks	Horse
	Cows	Buffaloes	Cow bull	Buff. bull	Cow males	Cow females	Buff. male	Buff. female		
Deaths	5	1	..	..	37	28	4	1	3	..
Condemnations	32	4	..	1	5	11	..	..	7	1

For the present the breeding policy of the farm is " Best to the Best " in the same breed, *i.e.*, Haryana to Haryana, Thar-parkar to Thar-parkar, in order to supply stud bulls with pedigree to improve the local breeds.

The farm also possesses a small herd of adult Murra buffaloes, 24 in number. These are maintained with a view of breeding by selection for supplying bulls of known milking qualities.

Ninety-six ewes (with two lambs) and 4 rams were purchased during the year from the Bikaner State. The object is to keep this breed pure and increase the wool outturn and quality by breeding by selection. These sheep will be kept on the farm throughout the year and not sent to a dry district during the monsoon. So far the health of the flock has been good, only 4 cases of gid have appeared. Fifty-nine lambs were born up to 31st March 1929 of which three died of natural causes.

The overall average milk yield of the Haryana herd was 1,950 lb., of the Thar-parkar 1,800 lb. and of buffaloes 3,600 lb. The following table shows the yeilds of 6 principal cows of the Thar-parkar and Haryana breeds and Murra buffaloes which completed their lactation period during the year :—

Thar-parkar cows.

No. of animal	Approximate age	Milk yield 1928-29	Days in milk	REMARKS
	years	lb		
71	9	5,918	428	Weaned.
119	9	5,482	367	"
149	8	4,612	398	"
53	10	4,506	305	"
182	10	4,111	372	"
208	6	4,093	401	Not weaned.

Haryana cows.

No. of animal	Approximate age	Milk yield 1928-29	Days in milk	REMARKS
	years	lb.		
186	6	5,387	295	Weaned.
76	9	4,473	338	"
142	8	4,219	287	"
145	6	3,966	302	"
78	9	3,859	299	"
164	7	3,831	303	"

Murra buffaloes.

No. of animal	Approximate age	Milk yield 1928-29	Days in milk	REMARKS
1	years 9	lb. 6,014	281	Weaned.
12	8	5,757	487	"
13	8	5,402	366	"
10	8	5,202	273	"
6	8	4,817	262	"
4	8	4,799	402	"

The method of disposing of milk produced on the farm was to feed as much as was required by the calves and then to separate a major portion of the remainder for feeding calves and to sell as much of the remainder as possible. The balance during the summer months was separated and the cream supplied to the Government Military Dairy, Ambala. During the winter the balance of milk was turned into cheese, which is sold during the summer months.

The farm was visited by many people during the year including some students from the Agricultural College, Lyallpur (Punjab).

Bangalore. Although the season for the 1928 monsoon crop promised well with 7 inches of rain instead of the normal 3·8 inches for July, and 6·5 inches in August instead of the normal 5 inches, a set back was received by a large decrease from the normal 8 inches in September to only 1·3 inches. In October we experienced an exceptionally heavy rainfall for Bangalore of 16·12 inches instead of the average of 5·4 inches, but it was of no material use for the growth of the monsoon crop. Full use could not be made of silo pits owing to less fodder being available.

During the financial year under review, the following new buildings were built by farm agency during the year :—

	Rs.
(1) Supervisor's quarters at a cost of	2,595
(2) Covered manure shed at a cost of	1,577
(3) Motor shed at a cost of	1,383
(4) Implement shed at a cost of	1,221
(5) A model cattle shed for 40 cows with the latest pattern stanchions at a cost of	7,628

The following new machines were purchased :—

- (1) One Astra N. S. R. Pasteurising Vat 55 gallons size at a cost of Rs. 1,257.

- (2) One Daisy 3 Cream Separator at Rs. 330.
- (3) One "Frisia" jacketed glass lined pasteurising tank 50 gallons at Rs. 1,806.
- (4) One 5 B. H. P. Lister portable pumping set at Rs. 2,056.
- (5) Three galvanised iron tanks for the storage of water at Rs. 450.
- (6) One "Morris" one ton truck for conveyance of bulk supplies of dairy produce at Rs. 3,835.

Wire fencing in many parts was replaced by Steel Pale fencing and buildings and machinery were maintained in good order.

At the commencement of the year, the adult herd consisted of 66 Scindi cows, 60 half-breds and twelve three-fourth breds, with one Ayrshire, two Sahiwal and one Scindi bulls. In addition, there were 11 Delhi buffaloes and 2 buffalo bulls. The young stock consisted of 101 female cow calves and 59 male cow calves, 6 female buffalo calves and two buffalo male calves of all ages.

During the year one Ayrshire bull was purchased at a cost of Rs. 1,988, a Friesland bull at a cost of Rs. 1,512, twenty-four Scindi cows were purchased from Karachi at an average cost of Rs. 467 each. Three bullocks were received by transfer from the Physiological Chemist at a cost of Rs. 50 each.

The following animals were condemned and sold during the year :-

	Rs.
14 Adult cows average price obtained being	67 each
2 Buffaloes	at 70 „
2 Male cow calves	at 18 „
2 Female cow calves	at 34 „
2 Bullocks	at 17-8 „
2 Ponies	at 36-8 „

Six young stock bulls were sold for breeding at an average price of Rs. 116.

Twenty-seven male calves and one female calf not required by the Institute were given away at birth free of charge.

The following animals died during the year :—4 cows, 2 heifers, 15 bull calves, 25 cow female calves, 1 buffalo male calf, 1 buffalo female calf, 1 bullock.

A small outbreak of foot and mouth disease occurred in April 1928 and a more serious outbreak in March 1929. There were no casualties during the first attack, but in the second attack six young cow calves died.

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The following table shows the yields of six principal cross-bred cows and of the same number of Scindi cows which completed their lactation during the year :—

Cross-bred cows.

Serial No.	No. of cows	Date of birth	No. of calving	Quantity of milk given in lb.	No. of days in milk	REMARKS
1	346-A	15th Oct. 1921	4	8,677	312	Half-bred Ayr. Scindi.
2	133	18th Oct. 1909	17	8,307	347	„ Ayr. Haryana.
3	379-A	8th May 1922	4	8,115	415	„ Ayr. Scindi.
4	420-A	2nd Oct. 1925	1	8,090	347	„ Hols. Scindi.
5	766	25th Sept. 1916	8	8,023	357	$\frac{1}{2}$ Ayr. Hansi.
6	434	13th Dec. 1914	8	7,818	397	$\frac{1}{2}$ „ Hissar.

Scindi cows.

Serial No.	No. of cows	Year of purchase and present approximate age		No. of calving since arrival	Quantity of milk given in lb.	No. of days in milk	REMARKS
		Year	Age				
1	11	1923	12 $\frac{1}{2}$	4	5,604	247	Average of 4 yields, 5,634 lb. Farm bred. With first calf weaned gave only 244 lb.
2	158	1923	6	2	4,584	365	
3	127	1923	11	1	4,472	316	
4	128	1923	12	1	3,987	260	
5	110	1927	9	1	3,923	365	
6	2	1923	11 $\frac{1}{2}$	5	3,723	355	

During the year the Farm herd produced 512,150 lb. of milk which was supplemented by a purchase of 25,170 lb. Lb. 350,140 of new milk were sold to British and Indian Military Hospitals, officers, civilians and troops at varying rates, the average selling price being Re. 0-2-11-9 per lb. Lb. 101,032 of milk were separated, and 8,412 lb. of cream and 3,793 lb. of butter were manufactured from milk produced at the Institute. 12,000 lb. of milk were used in the manufacture of cheddar cheese, the outturn being 996 lb. Of 92,620 lb. separated milk produced, 80,585 lb. were issued as feed of calves, and 5,658 lb. were sold.

During the year, the price of milk to officers and civilians was reduced from Re. 0-3-6 to Re. 0-3-0 per lb. The Institute is in a position to meet fully the requirements of the military garrison, and also of civilian customers who have been dealing with the dairy for a long time.

The policy of crossing half-bred cows by good Indian bulls of known pedigree still continues, while the best Scindi cows are being bred to Scindi bulls. One new Ayrshire bull and one new Holstein bull were purchased; they are being used for crossing the remainder of the Scindi cows.

The Institute was visited by a large number of visitors during the year including His Excellency Field-Marshal Sir William R. Birdwood, Commander-in-Chief in India.

The outturn of fodder from farm lands during the year will be found in Appendix II attached to this report.

Wellington. The farm consists of 115.25 acres of land, excluding 6.08 acres of the building site, as detailed below:—

	Acres
Arable	35
Grazing	20.71
Leased land	52.54
Forest land for fuel	7.0
TOTAL	115.25

Of the above land, five acres were put to potatoes with a view to clearing the land, 2.5 acres to Rhodes grass, 0.5 acre to lucerne and 47 acres to maize, *juar* and oats. The manure used was chiefly farmyard manure, supplemented by lime, bonemeal, sulphate of ammonia, sulphate of potash, concentrated superphosphates and groundnut cake.

Owing to the failure of the monsoon there was a decrease of 127,063 lb. in the outturn of fodder, and 36,272 lb. in the outturn of potatoes, as compared with last year, though more land was put to cultivation.

During the year, one model cattle shed, one bull pen, one calf shed and one milk recording room were constructed and one Bamfords' grinding machine was purchased.

All buildings, machinery and fixtures were kept in perfect repair throughout the year.

The total number of different classes and breeds of cattle maintained during the year was:—

Ayrshire cows	13
Jersey cow	1
Ayrshire Scindi	19
Ayrshire Sahiwal	5
Ayrshire Hansi	2
Ayrshire Jersey	1
$\frac{3}{4}$ Ayrshire Hansi	1
$\frac{3}{4}$ Ayrshire Scindi	7
Half-bred \times Half-bred	3
Scindi cows	12
TOTAL	64

The general health of the herd was good until July, when 30 and odd animals were affected by fever and bowel trouble, each case lasting for a few days only. During the same period foot and mouth disease broke out which went practically through the whole herd, and before the animals had recovered, rinderpest broke out. From these attacks, the farm lost 15 animals of the value of Rs. 8,700 as detailed below :—

From Rinderpest						Book value	
						Rs.	
Pure bred cows	.	.	.	.	.	2	3,600
Pure bred calves	.	.	.	.	.	4	900
Cross bred calves	.	.	.	.	.	3	No value
TOTAL						9	4,500

From Foot and mouth—							
Pure bred bull	.	.	.	.	.	1	1,900
Pure bred cows	.	.	.	.	.	1	1,800
Pure bred calves	.	.	.	.	.	2	No value
Cross bred cow	.	.	.	.	.	1	500
Cross bred calf	.	.	.	.	.	1	No value
TOTAL						6	4,200

The herd was again attacked with foot and mouth disease of a much more virulent type in March, and not one animal in the herd escaped infection. As the second attack came at the time when the majority of the animals were calving or were due to calve, many which would have become valuable calves died at birth or a few days after, and the milk yield was reduced by 50 per cent. on the previous year's outturn just at a time when it was most needed.

In addition, it affected the animals to such an extent that they will not be back to normal for at least a year. Some animals died of a bladder disease which appears to be peculiar to these Hills. As nothing is apparently known about the treatment of this disease, one animal was sent to the Madras Veterinary College at the request of the Director of Veterinary Services who wished to watch the case to see if the cause of the disease could be discovered.

The breeding policy of the farm is to establish a pedigree herd of Ayrshire cattle. With this end in view, one pedigree bull and seven pedigree heifers in calf were imported in October 1928—one bull and three cows to replace casualties and four cows to augment the herd. Since their arrival, 5 heifers have calved and produced one heifer and four bull calves. All pure Indian cows are being sired by Ayrshire bulls and all half and three-quarter breeds are sired by Sahiwal or Scindi bulls.

The yields of six pure bred and six cross-bred cows obtained during the year are as follows :—

Pure bred.

Serial No.	No. of cow	Names of cows	No. of days in milk	Quantity of milk given in lb.
1	6	Priestland's Miss Alberta 2nd	344	5,503
2	7	White hill Rose Marie	340	5,144
3	5	Priestland Audry	324	5,304
4	12	Priestland's Lucette	405	7,271
5	10	Cortachy Liz	323	4,641
6	9	Cortachy Patuffa 2nd	396	4,211

Cross bred.

Serial No.	No. of cow	Names of cows	No. of days in milk	Quantity of milk given in lb.
1	23	Marie	386	5,795
2	27	Milk Maid	270	6,065
3	117	Emerald	418	9,103
4	857	Madge	319	6,441
5	116	Ruby	362	6,771
6	114	Pearl	350	5,092

The value of dairy produce sold during the year was Rs. 77,700, as compared with Rs. 77,186 during 1927-28.

The outturn of fodder during the year will be found in Appendix III attached to this report.

Anand. The J. and E. Halls Refrigerating Plant which had broken down and which was replaced by a Lightfoot machine transferred from Pusa has been repaired and re-erected so that the Creamery has now ample refrigerating capacity.

A small casein grinding mill with a small oil engine to drive same was installed during the year, and one combined butter churn and worker worn out was replaced by a smaller machine of the same type. The plant and machinery generally was kept in good repair during the year.

Experimental work in the manufacture of *ghi* according to the ordinary country methods and with modern machinery was carried out, and the experiments in the manufacture and drying of casein by different methods, the manufacture of condensed separated and new milk and in the treatment of milk for despatch to Bombay were continued.

During the year the Creamery purchased some 940,000 lb. of new milk, manufactured some 66,000 lb. of butter, 3,500 lb. of *ghi* and 15,000 lb. of commercial casein, while 337,000 lb. of separated milk were sold for shipment to Bombay after pasteurising and cooling to various temperatures.

The combined receipts and expenditure of Bangalore, Wellington and Karnal Farms and the Anand Creamery for the year will be found in Appendix IV.

APPENDIX I.

Outturn of grain and fodder obtained from the Imperial Cattle Breeding Farm, Karnal, during 1928-29, as compared with two previous years.

Particulars	1926-27	1927-28	1928-29	DIFFERENCE	
				Plus	Minus
<i>Grains</i>	md. sr. ch.	md. sr. ch.	md. sr. ch.	md. sr. ch.	md. sr. ch.
Gram . . .	0 12 8	2,114 7 0	3,986 34 8	1,872 27 8	0 0 0
Barely . . .	138 5 8	381 32 8	127 10 0	0 0 0	254 22 8
Wheat . . .	4,745 20 4	4,207 26 0	6,222 19 0	2,014 33 0	0 0 0
Ziri . . .	3,056 1 4	2,816 2 4	4,701 27 2	1,885 24 14	0 0 0
Toria . . .	26 27 2	155 36 8	0 0 0	0 0 0	155 36 8
Maize . . .	45 20 0	0 0 0	0 0 0	0 0 0	0 0 0
Gur . . .	346 7 8	274 36 8	0 0 0	0 0 0	274 36 8
Sugarcane seed .	1,190 20 0	3,110 15 0	0 0 0	0 0 0	3,110 15 0
Juar . . .	10 0 0	0 0 0	0 0 0	0 0 0	0 0 0
Potatoes . . .	29 17 0	0 0 0	0 0 0	0 0 0	0 0 0
Sance seed . . .	0 0 0	42 0 0	0 0 0	0 0 0	42 0 0
Masri . . .	0 0 0	21 19 0	0 25 0	0 0 0	20 34 0
Sanee fibre . . .	0 0 0	8 30 0	0 0 0	0 0 0	8 30 0
Linseed . . .	0 0 0	0 0 0	26 30 0	26 30 0	0 0 0
TOTAL . . .	..	13,133 4 12	15,065 25 10	5,799 35 6	3,867 14 8
<i>Fodders.</i>	lb.	lb.	lb.	lb.	lb.
Anjan grass seed .	50	..	..	..	..
Charri green . . .	647,036	878,176	37,200	..	840,976
„ dry . . .	8,000	3,600	111,600	108,000	..
Feeding hay . . .	122,973	112,840	41,600	..	71,240
Green grass . . .	1,991,781	1,215,824	..	..	1,215,824
„ oats . . .	30,580	28,020	4,600	..	23,420
Rice straw . . .	109,845	281,200	230,000	..	51,200
Bhorsa mixed . . .	468,455	800,560	1,066,577	266,017	..
Green maize . . .	10,000	..	..	..	..
Thatching grass .	172,702	..	..	..	..
Charri silage . . .	..	..	3,000,000	3,000,000	..
Green barley . . .	..	..	1,000	1,000	..
TOTAL . . .	..	3,320,220	4,492,577	3,375,017	2,202,660

The amount of rainfall during the year 1928-29 (under report) was 18·80, as against 22·79 inches last year.

APPENDIX II.

Outturn of fodder grown on the farm lands during 1928-29, at the Imperial Institute of Animal Husbandry and Dairying, Bangalore, and the dry stock farm attached to it.

Where grown	Kind of fodder	Acreage	Outturn in lb.	Total cost	Cost per 100 lb.	REMARKS
Bangalore	Green guinea grass .	8.76	677,590	1,709 2 4	0 4 0	There was an outturn of 800 lb. maize seed also.
	" lucerne .	1.37	55,374	389 0 6	0 11 3	
	" <i>juar</i> and maize .	61.14	929,972	2,881 12 11	0 4 11	
	" grass .	..	295,490	338 2 0	0 1 10	
	TOTAL .	..	1,958,426	5,318 1 9	0 4 4	
Bommanpalli .	Green <i>juar</i> .	..	41,490	606 0 11	1 7 5	The dry outturn was 9,020 lb. hay, 22,550 lb. is the outturn on green basis.
	Hay or dry grass .	..	22,550	28 3 0	0 5 0	
	TOTAL .	..	63,950	634 3 11	1 4 1	
	GRAND TOTAL .	All green	2,022,376	5,952 5 8	0 4 8	

APPENDIX III.

Outturn of grain and fodder crops at the Imperial Institute of Animal Husbandry and Dairying, Wellington, during the year 1928-29.

TOTAL AREA OF THE LAND IN POSSESSION OF THE FARM			1928-29						Average rate per 100 lb.	REMARKS
Arable	Grazing	Building Site, etc.	Total area of land under cultivation	Total outturn in green	Total expenditure incurred on cultivation	Production rate per 100 lb.	Total fodder purchased in green	Total amount paid for purchased fodder		
Acres	Acres	Acres	Acres	lb.	RS. A. P.	RS. A. P.	lbs.	RS. A. P.	[RS. A. P.	
35	20.71	6.08	35.0	Fodder 553,187	8,880 1 9	1 8 1	*809,215	6,820 6 0	1 15 3	* Purchased as dry fodder, 323,686 lb., and reduced in terms of green as 1 : 2½ lb.
20	32.54	7.0	20.0	Potatoes 36,458			37,500	229 2 0	0 9 9†	† Purchased as green fodder.
55	53.25	13.08	55.0	589,645	8,880 1 9	1 8 1	846,715	6,549 8 0	..	

Statement showing receipts and expenditure of the Imperial Institute of Cattle Breeding Farm, Karnal, and the Govern

Heads of receipts	TOTAL RECEIPTS (COMBINED CASH AND BOOK DEBITS)			
	Karnal	Bangalore	Wellington	Anand
	Rs.	Rs.	Rs.	Rs.
<i>Dairy produce</i>				
On credit	13,205	67,487	56,258	59,647
On cash	1,702	6,551	7,913	3,526
On coupons . . . .	..	27,399	13,354	..
TOTAL .	14,907	1,01,437	77,525	63,173
<i>Capital receipts</i>				
Live stock (Dairy) . .	8,619	1,770	1,017	..
Live stock (Draught) . .	355	107	150	..
Plant and Machinery . .	..	..		20
TOTAL .	8,974	1,877	1,167	20
<i>Miscellaneous receipts</i>				
Sale of skins	81	14	..	..
Grain and fodder . . .	44,960	878	185	..
Other miscellaneous receipts	4,323	7,071	3,291	15,167
Fees from students . .	969	3,403	570	1,435
Service fees . . . .	..	21	..	..
TOTAL .	50,333	11,387	4,046	16,602
GRAND TOTAL .	74,214	1,14,701	82,788	79,795

DIX IV.

Animal Husbandry and Dairying, Bangalore and Wellington, Imperial ment Creamery, Anand, for the year 1928-29.

Heads of expenditure	TOTAL EXPENDITURE (COMBINED CASH AND BOOK DEBITS)			
	Karnal	Bangalore	Wellington	Anand
	Rs.	Rs.	Rs.	Rs.
<i>Supplies and Services</i>				
Lands, buildings, accessories	20,179	14,535	19,475	201
Plant and machinery . .	3,682	8,736	565	8,075
Purchase of dairy cattle .	14,551	15,761	16,104	..
Purchase of draught cattle	..	50	1,450	..
TOTAL OF CAPITAL ITEMS .	38,412	39,082	37,594	8,276
Rent and repairs to buildings	6,432	4,196	894	998
Repairs to plant, machinery and work-shop.	6,900	2,346	1,752	4,410
Feed of dairy cattle . .	35,315	44,448	22,589	..
Hire of cattle and purchase of dairy produce.	..	21,472	25,768	65,203
Ice, salt and acid preservatives, etc.	1,126	558	201	1,769
Cultivation charges . .	15,537	1,271	6,163	..
Fuel, light, water, miscellaneous stores.	6,650	17,840	4,490	19,163
Freight on stores . .	2,089	1,374	1,919	11,526
Medical stores . . .	957	..	3,193	..
Refunds of coupons and deposits and excess recovery of house-rent.	..	..	390	..
TOTAL OF REVENUE ITEMS .	75,006	93,505	67,354	1,03,069
Contingencies . . .	2,246	2,272	2,208	1,182
Establishments . . .	36,376	35,946	20,138	14,459
Allowances . . .	3,484	2,759	1,119	2,411
TOTAL .	42,106	40,977	23,465	18,052
GRAND TOTAL .	1,55,524	1,73,564	1,28,413	1,29,897

REPORT OF THE PHYSIOLOGICAL CHEMIST.

(F. J. WARTH, M.Sc.)

I. CHARGE AND STAFF.

Charge. Mr. A. Viswanatha Iyer held charge of the Section until the 25th October, 1928, on which date I assumed charge of the Section. While on leave, I was deputed for ten days to visit the Animal Nutrition Institutes at Cambridge and Aberdeen. A report on this tour was sent to Government.

Staff. Sanction has been received for the appointment of one Temporary Laboratory Assistant, one Temporary Computing Clerk, one Temporary Graduate Fieldman and one Temporary Laboratory Attendant. Steps are being taken to fill these appointments. In addition, sanction has been received for the following permanent appointments :—

1. One Sardar for cattle shed.
2. One Peon.

These posts have been filled.

II. LABORATORY WORK.

The following is a list of analyses completed during the year :—

Complete analyses :—		
1. Fodders	105	
2. Faeces	41	
		146
Dry matter in faeces, urine, silage grasses, green juar, etc.		2,835
Single nitrogen determinations in :—		
1. Fresh faeces	160	
2. Fresh faeces after pepsin treatment	257	
3. Milk	263	
4. Urine	69	
5. Miscellaneous	177	
		926
Mineral analyses in faeces, faeces, urine, grasses, etc.		188
Partial analyses of urine		7
Complete analyses of urine		154
Miscellaneous analyses :—		
Hippuric acid in urine	122	
CO ₂ in urine	112	
H in urine	64	
Butter	2	
Other samples	44	
		344
TOTAL		4,600

III. PLANS FOR THE ESTABLISHMENT OF A NEW ANIMAL NUTRITION INSTITUTE.

At the request of the Government of India and in accordance with the recommendations of the Royal Commission on Agriculture, I have prepared and submitted plans for an Animal Nutrition Institute. The original plans are at present being revised in the light of Government's views and will be ready for resubmission shortly.

IV. WORK OF SECTION DURING 1928-29.

1. *Experiments on nutrition of growing animals.* Under this head an experiment which is in progress at Bangalore deserves notice. The experiment is intended primarily to shed light on the nutritive value of gram husk. Various husks are used in India as cattle food and their value is not known at all. Three groups of calves are receiving respectively (a) cake and wheat bran, (b) cake and gram husk, (c) cake alone, coarse fodder being provided *ad lib.* to all. The test has not been completed, but it is already abundantly clear that gram husk has a distinct positive value.

Another very important experiment with young stock at Bangalore has been commenced with *ragi* (*E. coracana*) straw silage. This test will be referred to again later.

2. *Experiments on milk production.* During the year under report a series of tests has been undertaken to compare the values of typical Indian oil-cakes for milk production. In the first experiment linseed cake was compared with coconut cake, both the country and expeller cake being tested. Groups of cows fed on these cakes gave the following results :

	lb. of milk.
Linseed cake	4,712
Country coconut cake	4,509
Country coconut cake	4,213
Expeller coconut cake	4,443
Expeller coconut cake	4,338
Linseed cake	4,404

Linseed cake gave the highest yield. Expeller coconut cake came next. The total fat yield was determined at the same time. It was found to be as follows :—

	lb.
Linseed cake	130.6
Country coconut cake	140.7
Country coconut cake	129.7
Expeller coconut cake	129.8
Expeller coconut cake	135.2
Linseed cake	125.8

Linseed cake therefore produces more milk but country coconut cake produces slightly richer milk. More recent tests have shown that weight for weight linseed cake and groundnut cake produce identical amounts of milk with the same fat content. These experiments are being continued.

3. *Indian coarse fodders.* The work on coarse fodders has made very good progress during the past year. Extensive digestion experiments have been carried out with eight fodders from different parts of the country. Samples were obtained from Meerut, Bolarum, Talegaon, Saguri, Hosur and Bangalore. The data obtained in this very extensive work are not yet ready for discussion. However, with all the work that has been done, it should be possible, before long, to publish a tentative table of digestibilities of the commonest Indian fodders.

4. *Experiments on maturing of fodders.* It is well known that the stage of maturity exerts a very great effect on the nutritive value of a fodder. The Nutrition Section has undertaken the task of examining certain typical fodders at different stages of maturity. Several full tests have been completed during the year under report. The *juar* crop has been examined exhaustively at three stages of development. At each stage digestion experiments were carried out in the first place on the freshly cut plant as it came in from the field. Identical material was converted into hay and another lot of identical material was converted into silage. Digestion experiments were carried out with each. A mass of information has been obtained which is being prepared for publication.

Less elaborate tests have been made with other fodders. In this connection a test carried out in collaboration with the Military Grass Farm Department is worth referring to. At the request of the Nutrition Section, the Military Grass Farm made three cuttings of grass from a uniform plot at Bolarum. The cuttings were made into hay, and have been employed by the Nutrition Section for digestion experiments. In these three samples the best index of maturity is the protein content, as the following figures show :—

	Crude protein per cent.
1st Cut	5.56
2nd „	3.81
3rd „	1.98

The most striking figures obtained from the digestion experiments are those referring to crude fibre and protein. They were as follows :—

	Digestion coefficients	
	Crude pro- tein	Crude fibre
	per cent.	per cent.
1st Cut	44.8	76.0
2nd „	31.7	66.7
3rd „ . . . . .	..	57.8

These results show that the stage of maturity is a most vital factor in the nutritive value of fodders. The full data for these and similar experiments are being prepared for publication and arrangements are being made for further tests on similar lines.

5. *Mineral requirements of cattle.* The experiment with cows referred to in last year's report has been discontinued. Under the conditions of the test mineral supplements gave no benefit. Experiments on other lines are being prepared.

6. *Indian pasture grasses.* This heading is employed in connection with a specific line of enquiry organized by me and now entirely placed in the hands of Mr. A. Viswanatha Iyer, Senior Assistant to the Physiological Chemist. The enquiry aims at the determination of the mineral constituents of pastures under different typical soil and climatic conditions, using several pure species of grass for the test. The work is carried out in collaboration with the Bombay Department of Agriculture.

The enquiry has made considerable progress during the past year. The following figures exemplify the kind of information which Mr. A. V. Iyer is collecting on this important subject:—

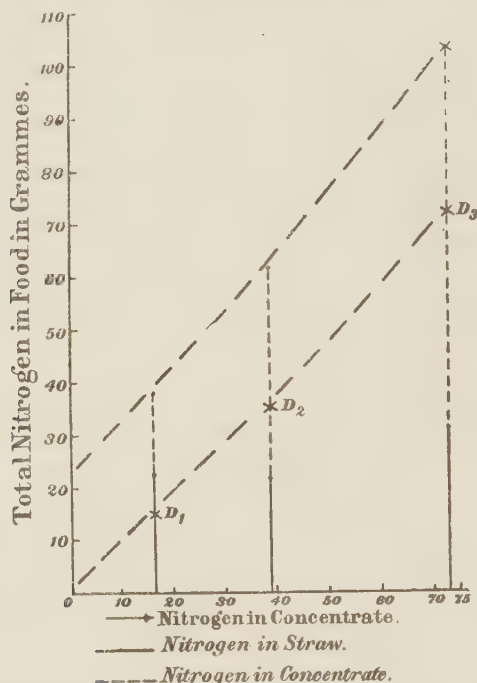
Minerals in 100 parts dry pasture grass.

Place	P ₂ O ₅		CaO		K ₂ O	
	early cut	late cut	early cut	late cut	early cut	late cut
Kalas Poona	·267	·076	·546	·501	0·876	·314
Belgaum	·798	·204	·549	·742	1·581	·685
Chharodi	·400	·166	·497	·391	2·342	·413

These are average figures derived from two pure cultures grown at each of the stations mentioned. Comment on the data is undesirable at this stage. It may be noted, however, that advancing maturity is associated with a decline in phosphorus. The lime generally does not decrease to the same extent.

7. *Protein digestion.* The general procedure employed in determining the digestibility of concentrates is to feed first a suitable roughage and determine its digestibility, the same roughage is then fed with concentrate and the digestibility of the combination determined. From the two sets of figures the digestion of the concentrate can be calculated. In such experiments it often occurs that the roughage alone is not relished. The animals eat irregularly and reliable figures cannot be obtained for the digestibility of the roughage. In such circumstances

the digestion of concentrates cannot be calculated with any degree of certainty. The Nutrition Section has had difficulty in obtaining reliable figures for protein digestion on this account and hence a new procedure has been adopted. The animal is never fed roughage alone. It receives roughage with regularly increasing amounts of concentrate. From three sets of digestion experiments, the protein nitrogen digestion is estimated by a graphic method. The following preliminary results obtained at Bangalore illustrate the process :



The total heights represent the total nitrogen (in grammes) consumed during each test. The points D₁ D₂ D₃ represent the total nitrogen digested. By extrapolation the amount digested from the straw alone can be found and hence the average digestion of concentrate nitrogen is determined. This procedure is also useful for determining whether protein digestion becomes less efficient with very rich rations. Arrangements have been completed for carrying out similar tests with a number of typical Indian concentrates.

8. *Silage*. Experiments on silage are proceeding on the following lines :—

(a) Preparation of green fodder silage under different conditions of moisture and at different stages of maturity. The points receiving attention are (1) fermentation losses, (2) chemical changes during the process of ensilage, (3) nutritive value as determined by digestion ex-

periments. *Juar* silage has been tested very fully in this way during the past year. The results are being prepared for publication. The chemical study is being carried by Mr. T. S. Krishnan of this Section. The following tables show some of the results obtained by him :—

TABLE I.

Dry matter changes during ensilage of Juar.

Bag No.	Dry matter put into bag before ensilage	Dry matter taken out of bag after ensilage	Loss of dry matter	Average loss	REMARKS
	kilos	kilos	per cent.	per cent.	
1 . . .	4.961	4.668	5.91	..	
2 . . .	3.358	3.241	3.48	..	
3 . . .	4.218	3.926	6.94	..	
4 . . .	4.433	3.964	10.58	..	
5 . . .	4.333	4.093	5.54	5.9	
6 . . .	4.176	4.103	1.75	..	
7 . . .	4.349	4.046	6.97	..	
8 . . .	4.161	3.950	5.07	..	
9 . . .	4.539	4.363	3.88	..	
10 . . .	4.262	4.056	4.83	..	

N.B.—In all the above cases the dry matter includes the volatile bases and acids.

TABLE II.

Crude protein changes during ensilage of Juar.

Bag No.	CRUDE PROTEIN BEFORE ENSILAGE			CRUDE PROTEIN AFTER ENSILAGE			Actual loss of protein	..	Average
	Crude protein in dry substance	Volatile bases	Total	Crude protein in dry substance	Volatile bases	Total			
	grams	grams	grams	grams	grams	grams	grams	per cent.	
1 . . .	460.6	4.5	465.1	245.9	150.8	396.7	68.4	14.7	
2 . . .	304.4	3.0	307.4	175.7	100.6	276.3	31.1	10.1	
3 . . .	375.0	3.9	378.9	226.8	123.3	350.1	28.8	7.6	
4 . . .	409.5	9.6	419.1	233.2	129.4	362.6	56.5	13.5	
5 . . .	402.4	11.4	413.8	225.4	128.0	353.4	60.4	14.6	
6 . . .	411.0	7.3	418.3	251.3	125.0	376.3	42.0	10.0	
7 . . .	356.8	5.6	362.4	248.4	107.3	355.7	6.7	1.8	
8 . . .	363.1	3.9	367.0	275.1	26.4	301.5	65.5	17.8	
9 . . .	444.6	4.0	448.6	340.0	40.8	380.6	68.0	15.2	
10 . . .	404.9	3.7	408.6	312.1	44.7	356.8	51.8	12.7	11.8%

The volatile bases have been calculated as crude protein.

It may be noted that the fermentation losses are low.

The loss of protein nitrogen is noteworthy. This work has been concluded and the results will be collected for publication in the near future.

(b) *Digestibility of carbohydrates of silage.* In numerous digestion experiments carried out by the Nutrition Section at Bangalore, a high digestibility of carbohydrates has been observed invariably. The subject appears to be important and therefore a chemical investigation has been commenced.

(c) *Preparation of silage from cereal straw.* If silage could be made from straw, it would undoubtedly be a very great boon as a hot weather feed in many localities. The Section has made attempts with *ragi* straw and wheat straw. The *ragi* straw silage is ready for experimental feeding. Until the tests have been carried out, nothing definite can be said about this material. Wheat straw silage, however, has been made and tested. It was eaten readily by cattle which could not be induced to eat the raw wheat straw. The silage was satisfactory in every respect. It was palatable and favourable digestion results have been obtained with it by the Nutrition Section at Bangalore. The Nutrition Section strongly recommends trials of wheat straw silage for the wheat tracts. It would provide a moderately succulent feed in the hot weather and would help to get the animals into good working condition for the monsoon ploughing. To prepare wheat straw silage, the Nutrition Section used 250 parts water for 100 parts straw. The material was well pressed.

9. *Physiological studies.* Some work under this head, *e.g.*, observations on diuresis and studies on hippuric acid production, have been in progress on a small scale during the past two years. The physiological work has now reached a stage at which it requires consideration in a separate section.

(a) *Diuresis.* Urination has been studied with 30 different rations during the year. Remarkable variations associated with certain fodders have been noted again. The highest figures this year were 15.1 K and 14.7 K as an average for two bullocks on a certain green fodder. A sample of green *juar* yielded 9.6 K. Some dry hay samples yielded less than 2.0 K. It appears that the stage of maturity of the fodder is likely to influence urination. To avoid misconception, it should be emphasized here that the degree of succulence of a fodder has no influence on urination. For example, fresh *juar* and the same *juar* converted into hay gave identical results. The observations on urination have still to be correlated with the composition of the fodders employed and with other factors.

(b) *Hippuric acid excretion.* It can be claimed that the past two years' work of the Nutrition Section at Bangalore has given a new significance to the question of hippuric acid excretion. In previous reports

from Bangalore, it was pointed out that hippuric acid excretion might cause an undue drain of nitrogen in certain cases. The work during the past year has proved that the acid base balance of the animal system is directly influenced by hippuric acid excretion, the reaction of the urine being dependent in great measure upon this substance. Furthermore, the amounts of hippuric acid eliminated, now that they are determined by a reliable method, are found to be serious in several cases. They indicate an unsuspected amount of potential benzoic acid in certain fodders. Griffith (*Journ. Biol. Chemistry*, 82, p. 415) has shown recently that in the absence of adequate supplies of glycine 2.51 per cent. benzoic acid in the food is fatal to rats. Quantities as low as 1.7 per cent. are harmful to growth. The toxic effect is greatly minimised by an adequate provision of glycine. When glycine is adequate, the benzoic acid is excreted almost quantitatively as hippuric acid.

In the ordinary foodstuffs used in Bangalore, no trace of benzoic acid has been found. But every fodder tested has been shown to contain precursors of benzoic acid which is liberated in the animal body when the food is digested. The potential benzoic acid content of various foodstuffs has been determined at Bangalore.

The following are typical results:—

	per cent.
Ripe <i>juar</i>	1.20
<i>Ragi</i> straw . . . . .	.97
Meerut hay	1.01
Groundnut cake	2.07

The quantity is liable to vary considerably according to conditions of growth and according to stage of maturity. The quantities of benzoic acid produced by some of our foodstuffs would be very harmful if adequate supplies of glycine were not available. In the fodders tested up to date glycine seems to be sufficient, because we have not met with any other form of detoxication of the benzoic acid than its combination with glycine. These results refer to maintenance rations only. Whether growth would be seriously affected with some of our fodders on account of the benzoic acid generated is a question which will require attention.

(c) *The acid base balance of the urine of cattle.* Preliminary observations showed that a study of this subject was likely to be most useful in differentiating foodstuffs and in other respects. The past two years' work at Bangalore has brought out a number of interesting facts. It has been found that certain fodders produce highly alkaline urines, others produce acid urines. Ranges of pH from 5.6 to 8.5 have been observed and every fodder is characterised by urine of fairly definite pH. That extremes of acidity and alkalinity are undesirable is shown by the efforts which the organism makes to moderate the alkalinity or acidity as the case may be. In this connection it has been observed

that the acid urines all contained ammonia, whilst the alkaline urines were ammonia free. The ammonia was evidently produced by the organism to reduce the acidity of the urine. The effect of this acidosis is parallel to that in which the urine becomes acid owing to faulty metabolism. In the Bangalore experiments, it should be noted, acidity of urine was due entirely to the nature of the food. That extreme alkalinity is likewise undesirable is shown in another way. It has been found in Bangalore that acid urines contained mere traces of CO_2 , whilst alkaline urines contained very large amounts. The organism is here endeavouring to reduce alkalinity by passing large amounts of CO_2 into the urine. Here again alkalinity of urine has been proved to be associated with definite fodders. Examples of results obtained at Bangalore are given below.

Examples of CO_2 content of acid and alkaline urines.

	pH	CO_2
Ripe <i>juar</i>	6.15	2.04
Do.	5.70	1.35
Young <i>juar</i>	8.1	59.25
Do.	7.9	50.00
Rhodes grass	8.5	30.18
Do.	8.4	25.06

CO_2 in c.c. N/5 in 25 c.c. urine.

One point of interest in this work is very easily explained. If we know which foods produce acid urines and which produce alkaline urines, it becomes a simple matter to adjust the urine composition by suitable compounding of fodders. It is quite possible that this principle will be of practical use in certain cases.

Going further into the subject, it has been found that the bases excreted (excluding ammonia) depend simply upon the amount of basic material present in the food. The acids are only partly of inorganic origin. The fraction of acids which has the controlling influence on the acid-base balance is of organic origin. The urinary organic acids have been estimated by electro-metric titration in a number of feeding tests with typical foodstuffs and it has been found that the major fraction of the organic acids consists of hippuric acid, hence the great significance of this acid in connection with the acid-base balance. Work is proceeding at present on the determination of total acid and base excretion with typical fodders.

V. TRAINING OF POST-GRADUATE STUDENTS.

Four students went through the post-graduate course during the year under report. Three students are undergoing training at present. Two special research students, one from the Punjab and the other from the United Provinces are also undergoing training.

VI. INSTRUCTION PROVIDED FOR DAIRY DIPLOMA STUDENTS.

The usual courses of lectures on chemistry and animal nutrition were given to the Dairy Diploma students.

VII. CO-OPERATION WITH OTHER DEPARTMENTS.

1. *Madras Department of Agriculture.* Feeding experiments were not carried out at Hosur this year. Instead, the Madras Department has greatly helped this Section by lending animals for experiments at Bangalore. The Hosur work will be continued as soon as the results of the completed experiments have been critically examined and prepared for publication. The Nutrition Section has carried out eight digestion trials with Hosur fodders during the past year. This work will be of mutual benefit to the two departments concerned.

2. *Military Farms Department.* The Section has again received very valuable samples from the Military Farms Department for feeding experiments.

3. *Bombay Department of Agriculture.* The work on pasture grasses has made excellent progress during the year.

VIII. PUBLICATIONS.

The work of publication has fallen in arrears for two reasons :

1. I have been absent on leave for part of the year.
2. On my return to duty I have had to spend a great deal of time on the preparation of schemes for a new Nutrition Institute.

Much work is overdue for publication. Three years' feeding experiments at Hosur, numerous feeding experiments on Indian hays and some maturing trials are the chief outstanding items. Now that a computing clerk has been sanctioned for the Section, it is hoped that this work will make rapid progress. Only one paper has been published, namely :—

“The Effect of some Oil Cakes on Milk Secretion” by the Post-Graduate students in the Animal Nutrition Section. (*Jour. Animal Husbandry and Dairying in India*, Vol. III, Pt. III.)

IX. PROGRAMME OF WORK FOR 1929-30.

Major subjects.

1. Experiments on the nutrition of growing animals. This work involves tests at Bangalore and Hosur.

2. Experiments on milk production, a continuation of the work reported this year.

3. A study of Indian coarse fodders, including determinations of maintenance rations and studies of nitrogen and mineral metabolism.

This is a continuation of the systematic work commenced during the past year at Bangalore.

4. Indian pasture grasses, the special enquiry described in this year's report.

5. Silage experiments on the lines laid down.

6. Physiological studies on the lines laid down.

Minor subjects.

1. A study of the chemical methods employed in the above enquiries.

2. Preliminary experiments for the initiation of work on other aspects of nutrition.

Training.

1. The training of post-graduate students, which is an important branch of the work of this Section, will be continued as usual.

2. For the Dairy Diploma students a course in general science, plant chemistry and nutrition will be provided by this Section.

REPORT OF THE GOVERNMENT SUGARCANE EXPERT.

(RAO BAHADUR T. S. VENKATRAMAN, B.A.)

I. CHARGE AND STAFF.

I held charge of the office of the Government Sugarcane Expert during the year under report, except for one month's leave from the middle of April to the middle of May and six weeks' absence towards the close of the year in Java on deputation to attend the Third Conference of the International Society of Sugarcane Technologists. During my absence, the Second Cane Breeding Officer, Mr. N. L. Dutt, held charge of the office in addition to his own duties.

Mr. N. L. Dutt was confirmed in the post of Second Cane Breeding Officer with effect from the 3rd April, 1929.

II. RESEARCH AND INVESTIGATIONS.

(a) *Cane breeding technique.* (i) *The Coimbatore isolation method.* The Coimbatore method of isolating parent arrows,¹ after artificially developing roots from the attached canes, again gave satisfactory results during the year. With the 'noble' or tropical types, it would appear desirable, for best results, to induce the rooting from 3 to 4 nodes and afford facilities for a full development of roots by using bigger pots. Attempts have recently been made elsewhere to improve on the Coimbatore method by using culture solutions for feeding the artificially developed roots.

(ii) *Influencing time of arrowing.* Experiments reported last year for influencing time of arrowing—with the object of crossing varieties flowering at different times—were continued. Smoking the plants for about an hour each day and for a period of two months previous to the usual time of arrowing, was found to hasten flowering by about four days. It was further found possible to influence the time of flowering by about a week by planting the varieties at different times and under different soil conditions. Further experiments have been laid introducing the application of different manures, along with differences in time of planting and soil conditions.

The same problem appears to have arisen elsewhere also. In the Philippines a cross pollination—ordinarily impossible—was recently secured by planting one of the parents at a different elevation. Growing

¹ Venkatraman, T. S., and Thomas, R. Sugarcane-breeding Technique—Isolation of live arrows from undesired pollen through artificial rooting of canes. *Agri. Jour. India*, Vol. XXI, Pt. 3, May 1926.

the parents in a hill station like Wellington in the Nilgiris might prove of use in this connection.

(b) *The breeding programme.* (i) *Large scale hybridization.* The idea of raising large numbers of seedlings of any promising combination suggested itself sometime back. It was thought that by this means one might be able to exploit fully the possibilities of the particular cross. Two such crosses, *viz.*, Co. 213 \times 214 and Co. 213 \times 281, formed the bulk of the seedlings grown during the year. The results, judged from the selections made, would appear to be satisfactory. The crossing programme in the future will therefore consist of two kinds of hybrids: one kind, consisting of but a few individuals and made with the object of forming ideas about the type of hybrid seedlings; and a second kind—perhaps consisting of but one or two combinations—made with the object of obtaining seedlings of economic value. The improvements in breeding technique made in recent years at Coimbatore have made it possible to carry on this large scale hybridization with considerable certainty about the parents employed.

(ii) *In-breeding.* The seedling Co. 205, now found useful in the Punjab and elsewhere, is a hybrid between a noble cane—Vellai—and the Coimbatore *Saccharum spontaneum*. This seedling possesses, however, certain defects such as an impure juice and late maturity for the conditions in the Punjab; and the cross was repeated more than once in subsequent years with the object of breeding a seedling like Co. 205 but without its defects. The results were, however, disappointing. Work was therefore started in another direction. Large numbers (over 2,000) of seedlings were raised from Co. 205—practically selfed—and a few promising ones selected from them. The best of these—Co. 229—though superior to Co. 205 in juice quality, did not possess the same vigour of growth as Co. 205. Large numbers of seedlings (over 15,000) were again raised from Co. 229 and certain of these appear to be of the type the station has been after for replacing Co. 205.

(c) *Breeding canes against diseases and pests.* Within recent years, the breeding of resistant strains has been receiving increasing recognition as a valuable aid in the fighting out of diseases and pests in agricultural crops. In the eighties of the last century Java demonstrated the practical application of this principle in fighting *sereh* in the sugarcane.

For breeding such strains the method adopted so far has been the employment of resistant or immune varieties as parents. It is conceivable that the resistance of such parents might be due to certain structural or other peculiarities in the variety. If by careful investigation these could be discovered, it might be possible for the breeder to work them into a new production with the definite object of securing resistance.

Certain observations made at Coimbatore showed the possibility of the existence of such structural or other peculiarities in the resistant

canes, and the idea received the approval of Dr. Brandes of the United States of America. Quite recently Dr. F. C. Hadden has expressed himself in a similar manner.

During the year, three investigations based on this principle were in progress at the station. The first was the selection, for the Punjab, of seedlings with leaves sufficiently narrow and harsh to render them resistant to *Pyrrilla* attack. The second was the systematic study of rind hardness in sugarcane with the object of producing seedlings comparatively more resistant to the attacks of the smaller animals. The third was the study of the leaves of sugarcane with the object of discovering any adaptations that might render them unwelcome to insect visitors.

(d) *The wild Saccharums*. Coimbatore was one of the first to cross *Saccharum officinarum* with *Saccharum spontaneum*. Constant attempts were made to gather together at Coimbatore the different forms of this species, and the present collection at the station would appear to include about nine forms, one of them from Lahore being of special interest as being quite a diminutive form. In the quality of juice these forms vary a great deal from about 2 per cent. sucrose in the juice to as much as over 8 per cent.

All the forms were studied in some detail during the year including their root systems. In morphological characters the Java form is rather different from the Coimbatore species. Experience both at Coimbatore and Java has shown that the blood of *Saccharum spontaneum* is sometimes an asset in a new seedling, and the extant forms of this species would appear to deserve a special study. It might be worthwhile to organize a special expedition to collect all the wild forms of this species available in India, as some of them might show characteristics that might ultimately be useful in the breeding work for India. Recently the United States of America sent out at considerable expense an expedition to the island of New Guinea and some very interesting forms similar to *Saccharum officinarum* were collected by that expedition. It should be less expensive and much easier to collect the available Indian wild forms and grow them at Coimbatore for a detailed study.

(e) *Cane nomenclature*. There exists at present a considerable amount of confusion in sugarcane nomenclature. The same variety is sometimes known under different names in different countries and the same name is sometimes applied to more than one variety. An all-world organization like the International Society of Sugarcane Technologists is in an advantageous position to effectively straighten the confusion in cane nomenclature, with the co-operation of the various cane-growing countries; and the above association has been interesting itself in this work for sometime. During its last session in Cuba it

appointed a Standing Committee and placed on that Committee, in the first instance, Mr. Noel Deerr and myself from India. In response to a questionnaire issued by the above Standing Committee, twenty-two descriptions were forwarded from Coimbatore, the descriptions being made by Mr. N. L. Dutt and myself.

The utility of the work in which Coimbatore has thus co-operated will be evident from the following instance of wrong nomenclature. Some years back a cane came to be somewhat popular in the plantations of Northern India under the name of Maxwell 10. By sending specimens to Java this cane has recently been identified to be the same as 247-B which has been found of some use in various parts of India. At more than one station both the above canes—really one and the same cane—were being grown for trial and records kept of yields. If their identity had been known earlier, it is obvious some unnecessary work would have been saved.

(f) *Inheritance of characters.* Observations were recorded on 1,500 seedlings of known parentage with a view to get indications on the inheritance of characters in the sugarcane. Rind hardness and the plan of development of roots were included in the study.

(g) *Morphological descriptions.* Morphological descriptions were recorded in North India of five more of the more promising of the newer seedlings.

(h) *Refractometer studies.* A large number of periodic refractometer readings of juices were made by the hypodermic syringe method of B. Viswanath¹ to test the utility of the method for comparing juice qualities of seedlings under trial and previous to their final selection. The work will need to be continued another season before deciding on its adoption at the station. The periodic readings revealed a definite drop in the total solid contents sometime previous to the flowering of the canes under study. Experiments have been designed to apply the method for following up the changes in the juices of the planted *sett* during and after the germination of the buds.

III. COIMBATORE CANES IN THE PROVINCES.

The spread of Coimbatore canes in the provinces is going on apace. During the 1928 winter tour in North India I saw some very striking examples of such spread in the United Provinces.

Co. 205 is holding its own in the Punjab in the unirrigated areas and under unfavourable conditions of growth. A newer seedling—Co. 285—has shown distinct superiority over Co. 205 at the Gurdaspur Farm and is being tested in the districts. By a process of a kind of

¹ Viswanath, B. Studies in the Chemistry of Sugarcane. *Agri. Jour. India*, Special Indian Science Congress Number, 1929.

'in-breeding' already described (Section II, *b, ii*), other seedlings—apparently better than either Co. 205 or Co. 285—have been obtained and would be released the next season.

Co. 290 is easily superior to Co. 213 in the United Provinces and is the more favoured of the two. In some parts of the United Provinces its performance is even better than was anticipated at the time of its first selection at Coimbatore. Its large and brittle buds, however, are found to be a handicap in certain parts, as they necessitate a more careful handling of the planting material.

Co. 205, a favourite under unfavourable conditions in Bihar, is reported to be spreading into the better class lands as well. While its easy and vigorous growth is an asset to the grower, its poorer juice and the greater difficulty of crushing are not liked by the miller. A new seedling—similar to Co. 205 but without the above defects—is desired in this province; and, as already indicated, work is in progress at Coimbatore to secure such a seedling.

Co. 223, which till recently was considered promising in the irrigated tracts of the Punjab and was therefore planted on such areas, is now found to be more susceptible to *Pyrilla* attack than the indigenous kinds. Its broader and softer leaves probably render it more attractive to the insect; and the selection of seedlings for the Punjab has accordingly been altered from this view point.

The Coimbatore seedlings are beginning to find a place in world literature; and in a recent¹ contribution the late Professor F. S. Earle observed that Co. 281 "seems destined to be quite widely planted (in Cuba) at least on the poorer more exhausted soils." In a very recent communication from Brazil it is mentioned that two of the factories there will be crushing a fair quantity of Co. 281. Co. 290 is another seedling which is showing promise elsewhere.

IV. RESEARCH AND INVESTIGATIONS BEARING MAINLY ON THICK CANE BREEDING UNDER THE SECOND CANE BREEDING OFFICER.

(N. L. DUTT, M.Sc.).

(a) *Hybridization and selection.* Taking into consideration the number of seedlings raised, the crossing operations during the season were very satisfactory. A feature of the hybridization programme was the attention paid to crosses that were not productive of a large number of seedlings last year. Vellai was the variety that was chiefly used as the female parent, in view of the fact that it yielded some good seedlings the previous season. Other female parents employed were, Maur. 1237, B. 6308, P. O. J. 100 and P. O. J. 2725. Poovan also flowered and was crossed with E. K. 28 and Maur. 131.

¹ *The Planter and Sugar Manufacturer*, Vol. LXXXI, No. 23, December 8, 1928.

The cross-breeding programme was very heavy, involving as many as 68 combinations. The total number of seedlings raised was about 100,000, out of which 19,000 were transplanted to the second ground nursery. This number is considerably more than in the previous two seasons. The selfs also were not a disappointment. Selfed seedlings were obtained from P. O. J. 2696, E. K. 28, Maur. 131, Manjav, D. 131, B. 3412, Q. 116, Co. 213 and S. W. 111. The success in selfing was chiefly due to the 'isolation' of the arrows into bigger pots, instead of transferring directly to the soil inside the 'isolation' sheds. Removal to the pots gave a better control over termites.

Growth and habit notes were recorded on the seedlings in the second ground nursery with a view to selection. In all, 1,048 seedlings were selected for chemical analysis, out of which 130 were finally selected for further trial. The selected seedlings were from 24 different combinations, Vellai giving the largest number, P. O. J. 2725 and B. 6308 coming next in order. Forty-eight seedlings were selected from the different general collections. A majority of the selected seedlings were rich in sucrose, particularly the seedlings of S. W. 111 the sucrose of which ranged from 18.48 to 22.95 per cent. in the juice.

The root systems of twelve promising selections were dissected, as also of the standard varieties from the various thick cane growing provinces. Special attention is paid to the study of the root systems in as much as, on the quality and quantity of the root system of a seedling, depend its adaptability and successful growth in a particular tract. Root dissections were also made of certain of the important parents.

(b) *Flowering habits of canes.* For the three arrowing seasons since 1926, twenty-six varieties were under observation with the object of studying their flowering habits. Out of the varieties at the Thick Cane Area, P. O. J. 2725 is the earliest to flower, while Lousier, Bontha and Batjan are among those which flower last, the interval between the first and the last to flower being nearly two months.

The time taken for the complete emergence of arrows varies according to the variety. In P. O. J. 2696 it emerged out fully in 15 to 17 days, in H. 109 and B. 6308 in 21 to 24 days, while in others it ranged between these two limits. In Vellai some of the arrows did not come out fully. Sugarcane varieties differ again with regard to the length of the protruded arrow when the flowers open for the first time. The flowers begin to open in Vellai after the arrow had emerged out about 6 to 10 inches, while in P. O. J. 2725 the flowers remained closed until the arrow had protruded about 18 inches. The shortest interval between the emergence of the essential organs of the flower, and the bulk dehiscence of anthers, was 15 minutes in the case of P. O. J. 1410. Next in order were D. 74, Striped Mauritius and Gillman with an interval of 20 minutes. The

maximum interval—40 minutes—was recorded in Co. 213 and Green Sport.

The above mentioned studies on the flowering habits of the canes were pursued rather in detail with regard to the sugarcane varieties employed in cross-breeding. These data, together with the notes recorded on the seedlings raised at the Thick Cane Area, helped in the drawing up of the hybridization programme.

(c) *Sugarcane pollen studies.* With a view to corroborating the results obtained during the last two seasons, but chiefly with the object of prolonging the viability of sugarcane pollen, the studies were continued.

(i) *Culture medium.* Tests made by varying the constituents of the culture medium and the size of the moist chamber showed that filtered rain water could be substituted for distilled water and that ordinary commercial white sugar and shred agar suit the artificial culture of the sugarcane pollen best. It was further found that it was not a necessary pre-requisite to have a glass ring 7.5 mm. in height and 17 mm. in diameter, successful artificial germinations having been obtained by employing any sized moist chamber ranging from 1.2 cm. to 15 cm. in diameter and 0.5 cm. to 1.5 cm. in height.

(ii) *Pollen tube growth.* The maximum length attained by a sugarcane pollen tube under artificial culture was by a P. O. J. 2696 pollen, when the tube measured 2921 after three hours growth. The pistils of the sugarcane varieties measure between 1/12 and 1/10 of an inch and it is not rare to come across pollen tubes measuring that much or more under artificial culture after a growth of about three hours.

(iii) *Pollen storage experiments.* Sugarcane pollen was stored alive for 96 hours and 168 hours in partial vacuum and corked and paraffined glass tubes respectively at temperatures varying from 9° to 13° C. The pollen inside the glass tubes was found to have caked. Glass ampoules were therefore substituted for the tubes. The results were discouraging again as the pollen caked and subsequently turned into a viscid liquid. The failure with the ampoules led to the keeping of the pollen over 85 per cent. relative humidity, in an atmosphere of CO₂ and at low temperatures varying from 5° C to 13° C. The desiccator containing pollen under the above conditions was placed inside a galvanized iron box which was kept at temperatures varying from 5° to 13°C. With this method, Maur. 131 pollen was kept viable for 12 days. To bridge over the disparity between flowering dates, which, as mentioned in the first paragraph under 'Flowering habits of canes,' may be more than a month, it will be necessary to store sugarcane pollen alive for that period.

(iv) *Enzymes and chemical analysis.* A study of the chemical composition and enzymes of pollen is helpful in understanding its physiology. The lack of certain enzymes may hinder the growth of the pollen tube

and result in non-fertilization of the ovary and failure of the cross that may have been effected. Tests were conducted for diastase, invertase, cytase, pectinase and the proteolytic enzymes. Sugarcane pollen was found to contain both diastase and invertase. Indications were also obtained of the presence of trypsin and pepsin, but the tests with regard to these and pectinase will need to be repeated for confirmation.

The chemical analysis showed the presence of 16.25 per cent. starch and 19.49 per cent. sugar.

(d) *Inheritance studies.* The following hybrid seedlings were studied to find out indications of inheritance for certain characters:—

	Seedlings.
Vellai × Maur. 131	250
Vellai × Q. 813	300
Vellai × D. 131	250
P. O. J. 1725 × Q. 116	900
P. O. J. 2725 × Co. 213	100
P. O. J. 2725 × Gillman's Red Sport	650
P. O. J. 2725 × P. O. J. 2696	450
TOTAL	2,900

The characters studied were bloom, colour of the cane, shape of the bud, spines on the back of the leaf sheath, and auricle.

V. RECEIPT AND DESPATCH OF CANES.

During the year four seedlings were imported from Tucuman. Over 100 consignments, chiefly of Coimbatore seedlings, were sent to various parts in India and ten packets overseas to Cuba, United States of America, Mauritius and Portuguese East Africa. Crossed seeds (fuzz) were despatched on request to Tucuman in the Argentina and Sydney, New South Wales. It would appear likely that there is less risk of importing diseases in the case of seeds than with setts.

VI. THE FARM.

Agriculturally the year was a bad one. The south-west monsoon was very disappointing and the north-east monsoon was below normal. Through planting early, the crop of paddy—the rotation crop in the wetland area—was ahead of the surrounding crops in growth and yield.

Gur or *jaggery* fetched during the year a higher price than in previous years. During some portions of the year *jaggery* was selling at Rs. 4 per maund of 25 lb. as against Rs. 3-8-0, the prevailing price of sugar per maund at the time.

The conversion of sugarcane trash into synthetic farmyard manure has become a routine practice at the station.

VII. TRAINING OF STUDENTS.

Five students sought training at the station. Mr. N. B. Patwardhan, of the Department of Agriculture, Bombay, was given a three months' training with special reference to cane description and identification. Messrs. Aime de Sornay and Emmerez de Charmoy from Mauritius were given a course for three months in the work of the station with special reference to sugarcane breeding. They are to take charge of sugarcane breeding work on their return. A private student, Mr. S. G. Honap, was with us for a period of six months and Mr. Kidar Lal Khanna, a B.Sc. from the Agricultural College at Lyallpur, is undergoing a full year course at Coimbatore. Messrs. N. B. Patwardhan and S. G. Honap had their training in the thick cane area under the Second Cane Breeding Officer, and the others at the area devoted to the breeding of thin and medium canes.

VIII. MISCELLANEOUS.

Building constructions. For over three years a heavy building programme has been in progress entailing a considerable amount of extra work on me, the Assistant Sugarcane Expert and the clerical staff. The cost of the constructions during this period amounted to about one lakh and a half of rupees.

Station Week. As during last year, a demonstration was arranged in December 1928 to which officers working on sugarcane from all over India and Burma were invited. Officers from Assam, Bengal, Madras, Bihar and Cochin attended the demonstration.

Visitors. The visitors to the station during the year included the Hon'ble Member of the Viceroy's Executive Council for Education, Health and Lands, the Hon'ble Pandit Madan Mohan Malaviya, M.L.A., Drs. Boeke and Vander Kloff from Java, and the Minister for Development, Madras.

The receipts during the year amounted to Rs. 10,534 (of which Rs. 2,720 represent rent from resident officers).

IX. PROGRAMME OF WORK FOR 1929-30.

Major.

The breeding of medium canes will be continued with the object of securing further improvements or covering new tracts.

The breeding of thick canes to suit the requirements of the thick cane-growing tracts of India will be carried on.

Further attempts will be made to improve the breeding technique and to secure greater germination among thick cane seeds.

Minor.

Studies on sugarcane roots and pollen and seed viability.

Studies on the inheritance of characters.

Morphological studies of sugarcane varieties (including flowering habits and floral characters), seedlings and wild *Saccharums*.

Study of chemical changes in the planted setts during and after germinations and the use of the Refractometer for selection work.

X. PUBLICATIONS.

- VENKATRAMAN, T. S., AND THOMAS, R. Studies of sugarcane roots at different stages of growth. *Mem. Dept. Agri. India, Bot. Ser.*, Vol. XVI, No. 5.
- VENKATRAMAN, T. S. . Problems for the Sugarcane Breeder (Forwarded to the Third Convention of the Int. Soc. of Sugarcane Tech. held at Java in June 1929).
Certain features of sugarcane root systems and the importance of their study.
- DR. PURI, A. N., AND VENKATRAMAN, T. S. An apparatus for testing rind hardness in canes. (The above two papers were forwarded to the 1929 Convention of the Sugar Technologists' Association (of India).
- VENKATRAMAN, T. S. . Supply of sugarcane varieties from the Imperial Sugarcane Station. *Agri. Jour. India*, Vol. XXIII, Pt. V, Sept. 1928.
What portion of the sugarcane to plant? *Agri. Jour. India*, Vol. XXIV, Pt. I, Jan. 1929.
Possible value of Coimbatore seedling canes to Cuban conditions. *Agri. Jour. India*, Vol. XXIV, Pt. III, May 1929.
- DUTT, N. L. . . . Studies in Sugarcane pollen with special reference to longevity. Accepted for publication in the *Agri. Jour. India*, Vol. XXIV, Pt. IV, July 1929.
Longevity of sugarcane pollen. *Agri. Jour. India*, Vol. XXIII, Pt. VI, Nov. 1928.

REPORT OF THE SECRETARY, SUGAR BUREAU.

(WYNNE SAYER, B.A.)

I. PREFATORY.

I held charge of the office of Secretary, Sugar Bureau, throughout the year under report. The subordinate staff remained unchanged. The Bureau which was created in 1919 is now in its eleventh year but still continues on a temporary footing. The Royal Commission on Agriculture in India has recommended that the Sugar Bureau along with other Bureaux should be placed directly under the Council of Agricultural Research. Accordingly the question of confirmation of the existing Bureau and the lines on which it should develop in future will be decided by that body.

During the year under report, the Bureau continued the collection of information relating to the sugar industry in India and abroad and made it freely available to the public. It already possesses a large quantity of valuable information which is being freely drawn upon by the public and the provinces.

II. AGRICULTURAL.

On the agricultural side, all the actual practical work on cane has been transferred to the Imperial Agriculturist, but the Secretary, Sugar Bureau, remained in close touch with it and assisted and advised both the Imperial Agriculturist and the Government Sugarcane Expert at Coimbatore, whenever necessary, in the selection of new types for the varied requirements.

Co. 290 and Co. 287 again showed promise, but I have yet to satisfy myself that they will suit all districts of the White Sugar Tract and whether they will prove a real advance over Co. 213 in those portions of the White Sugar Tract where the average rainfall is about 45 inches or less and no irrigation is possible.

The scheme of the Bihar Government for cane propaganda work in the province continued to work well. As a result of the premium offered by some of the sugar factories, a considerable extension of the area under Co. 214 has taken place. With the offer of the premium, a marked increase in tonnage has been noticed, due to this cane obtaining a better choice of land. Co. 205, which was definitely given out for bad high lands and *jheel* borders only, appears to have done so well with the free growers that it has now appeared on all classes of lands and the mills are considering the limitation of supply of this cane as it is extremely hard

to crush and does not show, to any marked extent, the characteristics of a good factory cane. Owing to the satisfactory behaviour of Co. 290 and Co. 287, particularly in North Darbhanga, it is hoped to arrange a mill trial with these two varieties during 1929-30. Work in Saran carried out with the Deputy Director of Agriculture, North Bihar Range, has resulted in the establishment of Co. 210, Co. 213 and Co. 214 in the Marhowrah area. In this connection it appears to me that the time is now ripe for a definite examination of the whole question of economic cane supply, waggon haulage and the kindred problems of the Indian sugar industry linked up in the zone system.

Co. 281 is highly spoken of in Cuba and Florida, and on the fact being brought to the notice of the different Provincial Agricultural Departments, small consignments of this variety were despatched from Pusa to the Central Provinces, Bihar and Orissa and Burma for trial.

Four important Tucuman seedlings, T. 472, 407, 393 and 518, were obtained during the year and passed on to the Government Sugarcane Expert, Coimbatore, for testing. If they are found promising, that officer will utilize them in crossing work.

The trial of P. O. J. 2878, the now famous Java cane, has also been arranged for the season 1929-30 at Pusa, the seed-cane having been obtained from the Government Sugarcane Expert, Coimbatore.

I visited Poona to attend a conference in connection with the Deccan Canals scheme of the Bombay Government, and continued to advise the Sahmaw Sugar Factory in Upper Burma regarding the selection and cultivation of improved varieties of cane.

During the year under review, an article on mosaic and its control in other cane-growing countries was published by me.

We are fortunate that in the area in which India's white sugar industry is chiefly situated those thick canes which are the chief sufferers from mosaic cannot be extensively grown as field crops on a large scale, while the prevailing types of Co. canes which have been given out show such tolerance that mosaic can no longer be regarded as an ever present danger, so long as growers take reasonable care in selection of seed and rogueing out of infected plants in the crop. Co. 205, which is the Co. cane most susceptible to mosaic in the district, is now being given up owing to mill objections, and tests are being made with Co. 285 and Co. 295 with a view to replace this variety, the outlook at present being promising.

III. INDUSTRIAL.

The number of sugar factories in India remained the same during the year under report. The factory at Supaul in the Bhagalpur District has been closed down, and a factory has appeared at Maharajganj. The

sugar factory at Lohat, District Darbhanga, has been greatly improved, its increased cane crushing capacity being at present the highest in India. The factory at Basti in the United Provinces, which is an example of a factory tapping a new area for its cane supplies, commenced work during the year. The Ishwari Khetan Sugar Factory at Luxmiganj referred to in last year's report also commenced working this season. One new sugar refinery at Thuckalay, South Travancore, was under construction and the factory management hoped to start work in the season 1929-30.

As usual, the Bureau kept in touch with all sugar factories in this country and gave advice when asked for. Figures of output for the working season 1927-28 were obtained from factories as well as refineries in India; and a consolidated statement of total sugar production in India was compiled and published in "The Indian Trade Journal" and "The Agricultural Journal of India". The production of sugar direct from cane in 1927-28 amounted to 67,808 tons, as against 63,057 tons in 1926-27; the total quantity of sugar refined from *gur* fell from 58,486 tons in the previous season to 52,055 tons in 1927-28. Thus the total production of sugar in India was 119,863 tons in 1927-28, as against 121,543 tons in 1926-27. It may be mentioned here that this fall is due to the marked decrease in the quantity of sugar refined from *gur*.

Reviewing the last four seasons' average percentage recovery of sugar direct from cane in the sugar factories, we find from the table below that there is a steady improvement.

Names of provinces	1924-25 Recovery per cent.	1925-26 Recovery per cent.	1926-27 Recovery per cent.	1927-28 Recovery per cent.
Bihar and Orissa	7.96	7.98	8.67	8.80
United Provinces	7.23	7.88	7.93	8.07
Bombay, Madras and Burma .	8.14	8.98	10.26	10.09
Total for India	7.81	8.07	8.49	8.62

Another table given below for the last 6 years shows clearly how the mass number of the factories are steadily increasing their efficiency.

	1922-23	1923-24	1924-25	1925-26	1926-27	1927-28
Total No. of factories working	19	22	23	23	25	26
Recovery percentage . . .	7.52	7.47	7.81	8.07	8.49	8.62
3 per cent. . . . .	..	..	..	..	1	..
4 per cent.	1	..	..	..	..	..
4.01 to 4.5 per cent. .	..	..	..	..	..	1
4.51 to 5.5 per cent. .	1	..	..	1	1	..
5.51 to 6 per cent. . .	1	5	3	..	..	..
6.01 to 6.5 per cent. .	3	4	5	1	1	..

	1922-23	1923-24	1924-25	1925-26	1926-27	1927-28
6.51 to 7 per cent. . . .	2	5	2	4	..	3
7.01 to 7.5 per cent. . . .	4	1	4	4	8	2
7.51 to 8 per cent. . . .	5	2	3	2	2	8
8.01 to 8.5 per cent. . . .	1	2	3	7	3	4
8.51 to 9 per cent. . . .	..	1	2	1	2	2
9.01 to 9.5 per cent. . . .	1	2	..	3	2	2
9.51 to 10 per cent. . . .	..	..	1	..	..	3
10.01 to 10.5 per cent. . . .	..	..	..	..	5	1
10.51 to 11 per cent. . . .	..	..	..	..	..	..
11.01 to 11.5 per cent. . . .	..	..	..	..	..	1

While this is satisfactory as far as it goes, it does not go far enough. Factories must keep constantly alive to improvements in their equipment and for any points or details which will reduce production costs, while the Agricultural Departments must increasingly test for canes with higher sucrose and heavier tonnage to enable factory improvements to pay for themselves on better results. In 1919 India's sugar industry was an object of mild solicitude, now it has reached the stage where it must move with the times, and if it cannot last the pace, it will go under. The influx of Java sugar will only be stemmed by increased efficiency throughout the industry. The industry is now past the stage where it was smiled at by other countries and is beginning to enter the arena of serious competition. It therefore behoves it to examine carefully the question of costs. In many ways the industry is hampered by the financial arrangements of fifty years ago. It still clings to bazar habits in its sugar marketing. It does not produce a standard grade, nor has it a standard name for its product. In short, it gives away too much through lack of unity. Further, and this point is one of vital importance, without a definite zone system and a cane prices board, trouble looms ahead and the future development of the industry cannot take place on the proper lines.

The imports of sugar through ports in British India in 1928-29 amounted to 868,800 tons valued at Rs. 15.86 crores as against 725,800 tons valued at Rs. 14½ crores in 1927-28. Java's production in the year 1928 was the highest on record and as Japan is now becoming less and less important as a buyer of the Java crop, the two principal markets for Java sugar are India and China. During the year under review prices of sugar in the Indian markets began to decline with the arrival of heavy shipments of the new Java crop. The following table shows the wholesale price per maund of ready Java white sugar in Calcutta.

The wholesale price per maund of ready Java white sugar in Calcutta.

1927.	Rs. A. P.	1928.	Rs. A. P.	1928.	Rs. A. P.	1929.	Rs. A. P.
1st July . . .	10 11 0	1st January . .	10 0 3	1st July . . .	9 15 0	1st January . .	9 2 0
1st August . .	10 6 0	1st February . .	9 12 0	1st August . .	9 11 0	1st February . .	9 5 0
1st September .	11 0 0	1st March . . .	9 13 6	1st September .	9 9 6	1st March . . .	9 1 6
1st October . .	10 8 6	1st April . . .	10 9 0	1st October . .	9 10 6	1st April . . .	9 9 0
1st November .	10 0 6	1st May . . .	11 2 0	1st November .	9 0 0	1st May . . .	9 8 0
1st December .	10 6 0	1st June . . .	10 15 6	1st December .	9 6 0	1st June . . .	9 5 0

IV. STATISTICAL.

Work on the statistical side includes the collection of import and export statistics for India as well as for principal sugar-consuming countries of the world, areas under sugarcane and beet in India and foreign countries, costs of production of *gur* and sugar, both white and brown, and total and *per capita* consumption of sugar in various countries of the world. A large number of enquiries are received for information on these points and the available information is supplied to the public.

The Bureau continued to obtain price quotations for various grades of *gur* or jaggery from the various *gur* centres in India and arranged for their publication in "The Indian Trade Journal." Quotations for Java white sugar at Sourabaya and for Indian factory-made sugar at Cawnpore, as also the figures of stocks of sugar at the principal ports in India which are recorded in the Bureau, were made available to the Director-General, Commercial Intelligence and Statistics, Calcutta, for publication in every weekly issue of "The Indian Trade Journal."

The Bureau continued to furnish the Department of Commercial Intelligence and Statistics, Calcutta, with brief reviews of the sugar crop conditions in the world for incorporation in their all-India sugarcane crop forecasts published in August, October and February. For the information of those interested in the sugar trade, the Bureau continued to contribute notes to "The Indian Trade Journal" on production, imports and exports of cane and beet sugar crops of the world. A publication of the Sugar Bureau which the trade await with great interest is the Review of the Sugar Trade in India which is issued annually.

The Sugar Cable Service, which this Bureau has been conducting for the last seven years, is designed to obtain and distribute early and reliable reports of crop and market conditions in the principal sugar-producing and sugar-consuming countries of the world. It is still being conducted on the principle that the costs should be met by the firms or individuals obtaining the benefit of the service. Hitherto it has been so managed as to pay its way. The subscribers are from Bombay, Karachi, Cawnpore, Calcutta and Madras; so the service serves an all-India purpose.

V. MISCELLANEOUS.

Library. During the year under report, 212 volumes were added to the library. These were received either by purchase, exchange or free supply or by binding loose copies of the periodicals obtained in the library. Those interested in sugar manufacture and sugarcane cultivation consulted the library in person or took books on loan.

Publications. Thirty-nine notes giving statistical information regarding estimates of production, and exports of sugar in Java; production of sugar in Hawaii, the Sugar Industry in Mauritius, Netal, Argen-

tina, Philippines and the British West Indies and estimates of area under sugar beet in Europe were published in "The Indian Trade Journal". Besides one note on sugar production direct from cane in 1927-28, the following two articles were published in the *Agricultural Journal of India* :—

- (1) "The cane position in North Bihar with special relation to factory industry and the early crushing problem" by Wynne Sayer. (XXIII, part 6.)
- (2) "Mosaic and its control in other cane growing countries" by Wynne Sayer. (XXIV, part 1.)

An article on "Sugar Manufacture in India" by the present writer, was also contributed to the weekly journal "Capital" of Calcutta for publication in its Industries Supplement issued in December, 1928. Mention has already been made of the Review of the Sugar Trade in India during the year 1927-28 issued during the year under report.

Museum. Samples of Indian factory-made sugar were obtained in the working season 1927-28 and these replaced the old ones in the Museum. Samples of British refined, German granulated B. R. B. (Czechoslovakia) and French crystals have been obtained and placed in the Museum so that the Indian factory-made sugars can be compared with them.

VI. CONCLUSION.

The year under report has been one of test prices and the whole sugar world has at last risen and attempted to organize some action which will bring relief, while the very drop in prices has brought a similar cutting of costs in all those countries whose industry is in a condition of live efficiency. The Indian industry shows distinct signs of vitality. Its efficiency is slowly increasing and both on the agricultural and manufacturing sides results are in evidence. The time has now arrived for the industry to take stock of itself and the foundation on which it is built, as the importance of developing along the right lines cannot be too strongly urged. In the days of its infancy the only problem for the industry was one of individual cane supplies and factory efficiency ; now collective organization, effective control and, above all things, a united policy have become urgent matters and the industry must act and move as an all-India industry and not as a set of provincial units suffering from local whims and parochial prejudices. It has before it excellent examples of organization in Java and Hawaii. In this respect it can certainly directly benefit from the experiences of other countries, and it is to be hoped it will realize this fact and take the necessary steps as soon as possible.

